RURAL MUNICIPALITY OF ROSSER

By-law No. 2-17

BEING a By-law to provide for the protection of the surface water drainage system for the eventual build-out of the CentrePort lands within the Rural Municipality of Rosser

WHEREAS *The Municipal Act* of Manitoba C.C.S.M. c. M225 provides as follows:

"Guide to interpreting power to pass by-laws

231 The power given to council under this Division to pass by-laws is stated in general terms

(a) to give broad authority to the council and to respect its right to govern the municipality in whatever way the council considers appropriate, within the jurisdiction given to it under this and other Acts; and

(b) to enhance the ability of the council to respond to present and future issues in the municipality.

Spheres of jurisdiction

232(1) A council may pass by-laws for municipal purposes respecting the following matters:

(a) the safety, health, protection and well-being of people, and the safety and protection of property;

(h) drains and drainage on private or public property;

Exercising by-law making power

232(2) Without limiting the generality of subsection (1) a council may in a by-law passed under this Division

(a) regulate or prohibit:

(d) establish fees or other charges for services, activities or things provided or done by the municipality or for the use of property under ownership, direction, management or control of the municipality;

(e) subject to the regulations, provide for a system of licences, permits or approvals, including any or all of the following:

(i) establishing fees, and terms for payment of fees, for inspections, licences, permits and approvals, including fees related to recovering the costs of regulation, (iii)prohibiting a development, activity, industry, business or thing until a licence, permit or approval is granted,

AND WHEREAS the Rural Municipality of Rosser has completed a Drainage Study for the Rosser CentrePort Lands, evaluating the current state of the surface water drainage system including policies, standards, and mitigative measures to ensure the protection of the system for the eventual build-out of the Rosser CentrePort lands;

AND WHEREAS pursuant to the Water Rights Act the Municipality and any developers within the Municipality are required to obtain a General Drainage Rights License from Manitoba Sustainable Development.

AND WHEREAS it is in the best interests of the Municipality to obtain a General Drainage Rights License for the Rosser CentrePort lands.

NOW THEREFORE the Council of The Rural Municipality of Rosser in open council assembled enacts as follows:

1. That the Rosser CentrePort Lands Drainage Study document, attached hereto and forming part of this By-law, is hereby adopted.

2. That upon adoption of the CentrePort Lands Drainage Study, that the Municipal Administration be directed to obtain a General Drainage Rights License from Manitoba Sustainable Development for the Rosser CentrePort Lands.

3. That all developments, building and construction in the Rosser CentrePort Area be required to comply with the CentrePort Lands Drainage Study and the General Drainage Rights License.

4. That once the General Drainage Rights License is granted that it be utilized by the Approving Authorities, including the Special Planning Area (development approval) and South Interlake Planning District (construction and building permits) as the guideline for approval for developments and building construction within the Rosser CentrePort Area subject to any circumstances which require modification of the drainage unique to the development.

5. That the Municipality charge a fee of $250.00 for the processing of the application and all professional fees incurred by the Municipality for the review of the application shall be the responsibility of the property owner and/or developer.

6. All municipal fees associated with the review of a drainage plan and lot grading pursuant to a development application will be the responsibility of the property owner and/or developer.

7. Any outstanding municipal fees not paid within 30 days of the invoice shall be added to the property taxes of the land of the property owner.

8. That the Municipality will enforce the proper construction of drainage pursuant to this by-law through the Municipal Enforcement By-law, as amended from time to time.

9. That the Rosser CentrePort Lands Drainage Study By-law shall take force and effect on the date of third reading of this By-law.

DONE AND PASSED as a by-law of The Rural Municipality of Rosser at 0 077E PR 221, Rosser in the Province of Manitoba this 28th day of February, A.D. 2017.

Reeve
Frances Smee

Chief Administrative Officer
Beverley Wells

Read a first time this 24th day of January, A.D. 2017.
Read a second time this 14th day of February, A.D. 2017.
Read a third time this 28th day of February, A.D. 2017.

ROSSER CENTREPORT LANDS
DRAINAGE STUDY

This report evaluates the current state of the surface water drainage system and recommends Policies, Standards, and mitigative measures to ensure the protection of the system for the eventual build-out of the Rosser CentrePort Lands.

Printed: Dec 21, 2016

By: Jessica Manness, B.Sc., P.Eng

PROVINCE OF MANITOBA
J.A. MANNESS
Member
23874
Dec 21, 16
REGISTERED PROFESSIONAL ENGINEER

JME World Consultants
Box 54 Grp 17 RR2
Dugald MB R0E 0K0
204-330-1773
www.jme-consultants.com

ROSSER CENTREPORT LANDS DRAINAGE STUDY

EXECUTIVE SUMMARY

The Municipality of Rosser (Rosser) commissioned the Rosser CentrePort Lands Drainage Study to aid in the planning, maintenance, and enforcement of municipal drainage works within the portion of the municipality which is known as the Rosser CentrePort Lands Drainage Study. Therefore, the Rosser CentrePort Lands Drainage Study documents the existing conditions of the drainage system, assesses the potential changes that will occur with the development of the lands as planned for in the Inland Port Special Planning Area Development Plan, and recommends guidelines and Standards that will aid in the preservation of the balance between the environment and the developments.

The report discusses the factors that influence surface water runoff and water quality and reviews methods to predict the runoff. Secondly, the report reviews the regulatory requirements for runoff that transitions into the jurisdiction of other regulatory authorities. Finally, the report recommends runoff control measures within the Rosser CentrePort Lands to mitigate downstream impacts. Along with the runoff volume management strategies, additional strategies are recommended to encourage a sustainable approach to development.

Overall, it was found that drainage must be managed at multiple levels; that is,

(a) Drainage channels and structures that are already existing require inspection, maintenance, and/or replacement
(b) Development planning must include drainage planning and post-development runoff and water quality control measures, in compliance with applicable Codes and Standards
(c) Detention areas must be established to provide high-flow flood relief opportunities
(d) Land adjacent to waterways should be set aside as habitat buffers and corridors

The Inland Port Special Planning Authority and Development Review Committee are in place to facilitate the development process. Likewise, there are many stakeholders that need to be involved in the surface water management of the Rosser CentrePort Lands. It is therefore important that all stakeholders participate in the planning and maintenance of the drainage systems, and open communication is maintained throughout the build-out process.

Through adoption of the drainage management strategy outlined herein, it is anticipated that the Rosser CentrePort Lands will be developed in an environmental and socio-economic manner. Moreover, the drainage planning recommendations highlighted herein represent best management practices that demonstrate the Municipality's commitment to environmental stewardship.

FOREWORD

This report is prepared by JME World Consultants for the Rural Municipality of Rosser as per the March 2015 JME proposal and Council Resolution dated June 2015.

The work and analysis documented herein represent the professional engineer's carefully compiled study in compliance with the Professional Engineering Act. Several sources of data are relied upon for the analysis and these have not been verified for the accuracy. Although this report was completed using the highest quality of surveying, drafting, and engineering, there may be existing conditions that could not be observed during this study. Moreover, as time passes, unforeseeable events may occur which could not have been predicted within the current planning and under the expected hydrological regime. As such, the engineer assumes no liability for any costs incurred by subsequent discovery or resulting from impacts of such conditions.

The source data and analyses remain the intellectual property of JME World Consultants and/or third parties. Where the results of other reports are included for the analyses of this drainage report, the source is cited.

This report was compiled for the Municipality of Rosser and is to be shared with third parties only as agreed to, and as provided by the client and the consultant engineer.

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1 INTRODUCTION

The Rural Municipality of Rosser (Rosser) is located north west of the City of Winnipeg, with the Rural Municipalities of St. François Xavier and Headingley to the south, and the Rural Municipalities of Woodlands, Rockwood, and West St. Paul to the north and east. The total Rosser municipal land area is approximately 443 km^2, with the primary land use being agricultural. There are 4 pockets of concentrated communities in which the majority of the population of the Municipality resides.

Through agreement with the Province of Manitoba, CentrePort Canada, and the Federal Government, approximately 45 km^2 (11,000 acres) of Rosser's land is set aside for the Rosser CentrePort Lands development. The Rosser CentrePort Lands are located at the south-east corner of the Municipality where the lands can easily be accessed for most forms of shipping and transportation. Detailed maps of the Rosser CentrePort Lands are included in the appendix of this report.

The development objectives for the Rosser CentrePort Lands are described in the Inland Port Special Planning Area Development Plan, M.R. 48/2016. Primarily, the vision of the planned area includes transportation, trade, manufacturing, distribution, warehousing, and logistics centres. Land use will also include ancillary uses that support the tri-modal shipment exchange; that is, public works structures and infrastructure such as roads, rail lines, and airport access. Specific zoning requirements are described in the Inland Port Special Planning Area Regulation.

Figure 1: Capital Municipalities (Government of Manitoba, 1999)

1.1 ROSSER'S COMMITMENT TO SUSTAINABILITY

Rosser is committed to the sustainable development of the Rosser CentrePort Lands, which includes planning and management of the watershed. It is envisioned that the Rosser CentrePort Lands will be developed as an intermodal shipping, manufacturing, and industrial area with pockets of commercial, public, and green spaces that promote the social well-being of personnel, clientele, and neighbouring residences, while focusing on the systems required for successful business and commerce. Each of the land uses described above typically introduces a different amount of hard surfacing, trees, and grasses, which then impacts the stormwater runoff to surface water bodies and groundwater. In anticipation of the changing physical environment, Rosser has commissioned this drainage study.

The leadership objectives for the jurisdictional drainage management include:

- Control and (to the practical extent) eliminate water pollution and sediment transport to safeguard the natural and human environment.
- Protect and improve the surface water quality, wherever possible.
- Protect groundwater quality and quantity.
- Mitigate erosion and topsoil losses.
- Improve streambank and road embankment stability.
- As much as possible, prevent flooding risks on private land, near structures, and adjacent to infrastructure.
- Maintain the natural hydrologic cycle and function of the watersheds through the implementation of Land Development Design Standards.

Figure 2: Sustainability Focus

2 OBJECTIVES

This drainage study aims to provide guidelines for the sustainable planning and development of the Rosser CentrePort Lands. The drainage study objectives are as follows:

- Determine existing subcatchment areas and plan future runoff routing directions (i.e. post-development subcatchment areas).
- Realize the pre-development flow rates, runoff volumes, and flow velocities for subcatchment areas.
- Determine the critical flow-constricting points along the existing drainage routes and document existing flooding-prone areas.
- Recommend system relief options to reduce the probability of future flooding at existing flood-prone areas.
- Calculate the increase in stormwater runoff rates and volumes that would occur if no on-lot runoff control measures were applied.
- Recommend regulatory-owned detention areas and flow control measures.
- Evaluate and recommend solutions to surface water pollution.

- Quantify the benefit gained through the application of on-lot and municipal stormwater control measures.
- List recommended drainage control measures for lots and public areas to reduce the post-development runoff from developed areas.
- Recommend items for inclusion in a drainage policy including Design Standards, materials, and installation techniques.

3 DEVELOPMENT IMPACTS ON STORMWATER RUNOFF

The development of land for commercial, industrial, manufacturing and many public uses in the Rosser CentrePort Lands area includes the conversion of existing agricultural fields into building sites, paved sites, landscaped areas, and roads. Currently the region is mostly comprised of farm yard sites, farm-related industry, gravel mile-grid roads, and perennial and annual crop lands. This results in a shift to the way stormwater is dissipated from the land and also changes the sediment and bonded particle transport processes.

Stormwater runoff volume, velocity, and particle transport vary depending upon the following factors:

- Surface grades,
- Soil type,
- Surface material type, and
- Antecedent conditions.

These factors are discussed in the next sections.

3.1 INFLUENCE OF SURFACE GRADES

The only two factors which may be influenced by design include the surface grades and material types. Typically, the natural grades within the Rosser CentrePort Lands are very shallow, approximately 1 mm drop per 1 m distance traveled (<0.1%). Field drains and natural swales are used to collect the water from portions of the section. Next, municipal ditching around the sections facilitates the drainage for agricultural use by providing grade relief.

When the land is developed, the natural grades are insufficient for the intended land use. This would result in ponding around structures and water damage to property items. Typical development area grades are expected to be in the range of 5 to 30 mm drop per 1 m horizontal distance (0.5% to 3%), which prevents runoff from accumulating around foundations, prevents saturation and potholes in paved surfaces, and provides a dry location for walking, loading, and moving equipment on the lot. On lots with large square-footage buildings, the grades tend to be in the higher range to accommodate the flat floor while still providing positive grading of the lot.

Within development areas, typical Policies stipulate that one lot cannot drain its surface water through an adjacent privately owned lot. Common practices that prevent the cross flow include ditching, matching grades, or blocking the flow with dikes, curbs, or retaining walls. In a multi-lot subdivision and where the grade allows, developers may include a ditch between the backs of the lots. As with the field drains in agricultural fields, the shared swales facilitate better grades relief while providing a location for temporary storage of stormwater.

3.2 INFLUENCE OF SOIL TYPE

To evaluate the stormwater runoff changes following the development of the Rosser CentrePort Lands, it is important to understand the physical characteristics of the land and the current environmental processes which are influencing the stormwater runoff. There are three distinct soil areas within the Rosser CentrePort Lands Drainage Study area. These include (a) the south and west glacial lacustrine areas, (b) the north-east glacial till dominated area, and (c) the pockets of flood prone lands.

With respect to soils characteristics of the south and west Plan Area soils, these are typically fine textured Black Chernozems or Humic Greysols, 100 mm to 400 mm thick (which includes an organic rich A horizon), developed primarily from glacial-lacustrine clay deposits, silt, and rootlets. This layer is frequently referred to as "topsoil" by engineers, and should be removed to expose un-weathered firm clay or glacial till prior to the construction of roads, parking areas, and structural foundations. In some areas, the topsoil materials are shallow and underlain by a stoney glacial till while in other areas the Chernozems are followed by a deep thickness of impervious clay soils which continue to a greater depth which overlay the glacial till. In the Plan Area the surface soils are typically rated as Class 2 or Class 3 for agricultural capability (prime agricultural land) with moderate to moderately severe limitations restricting the range of crops that can be grown, or requiring additional management practices due to inadequate natural drainage (Agriculture and Agri-Food Canada, October 1999). The land with these characteristic soil types typically drains towards the Omand's Creek watershed subcatchment.

The north-east portion of the Rosser CentrePort Lands Drainage Study Area is characterized by loamy lacustrine soils with pockets of sand and gravel extending from the surface to the glacial till. The glacial till is typically stoney of shale origin with silt and clay intermixed and forming discontinuous clayey veneers. Little Mountain Park is an example location where the gravel till is mounded in a pocket of glacial till deposits and the till is visible at the surface. Meanwhile, within the park and slightly north of the park the clay lenses within the till create semi-impermeable liners which are known to suspend pools of water. The land within this portion of the study area has marginally better drainage patterns than the land to the south and west, and is gradually graded towards the Grassmere Creek watershed. Nevertheless, the capacity of this land is limited by poor natural surface drainage inherent to the low-sloped clayey soils. However, where there are coarse soils near the surface, stormwater filtration and infiltration beds would be an excellent mode of surface water management.

The flood-prone areas are shown on the attached Map labeled "Flood Prone Areas". Portions of the highlighted areas are characterized by wet, deep organic soil deposits overlaying impermeable lacustrine clay and glacial till. The flood-prone areas are subject to flooding during extreme stormwater events and during spring freshet due to the confluence of multiple natural drainage channels, flat natural grade, and incised downstream channel. As these locations have historically received and detained large volumes of stormwater from the upper reaches of the drainage routes, they are also a depository for organic matter and a sink for soil nutrients such as phosphorous. A majority of the land that is labeled as flood prone areas are currently in a natural state, pastured, or hayed in dry years.

Please note that the collection of detailed topographic and surficial soils data was beyond the scope of this study, and therefore portions of the land which is labeled as flood-prone may be suitable for other uses (such as development).

It is important to recognize the flood-prone areas as existing stormwater detention areas, yet maintain the quality and value of the areas. That is, a plan for the maintenance and enhancement of the detention areas is necessary to ensure the continued environmental and physical benefits. Development and use of one of the flood-prone area as a snow pile accumulation site may provide additional benefits for the Plan Area.

In its existing condition, the Rosser CentrePort Lands are primarily an agricultural area, and any rainfall onto the land is removed from the land in the following ways. First, up to 25% of the rainfall is absorbed directly into the foliage of young, actively growing vegetation (this is called canopy interception). When the remaining rainfall hits the ground, the organic soil layer acts as a sponge that holds up to an additional 25% of the rainfall and permits the slow uptake of water by the roots of the vegetation (this is called root uptake). Next, undulations in the soil caused by the coarseness of the soil surface and bulges caused by roots budding at the surface act to slow any lateral stormwater movement from the site and supports the on-the-ground processes. Saturation and infiltration into the deep soil layers is important for groundwater recharge; however, due to the impermeable clays in most of this region, saturation is an insignificant mode of stormwater dissipation and only accounts for approximately 10% of the natural stormwater dispersal in clayey soils. By contrast, saturation and infiltration is much higher in the coarse-grained soils of the north-west portion of the Plan Area, where infiltration may account for 50% of the stormwater dispersal. Simultaneously with the other processes, evaporation can be a significant mode of stormwater removal. The rate of evaporation depends on the air temperature and humidity, and may account for 5 to 30% of the stormwater dispersal.

Where the soil layers are permeable (i.e. gravel beds and fine sands or silts), the absorbed water that passes through the upper soil layers acts to recharge the deeper aquifers. Where the soil layers are non-permeable (heavy clays), less water will be absorbed and the runoff water will follow the grade of the heavy clay below the shallow organic soil layer and then drop out of the soil at natural or constructed breaks in the surface such as naturally occurring silt or gravel seams, constructed open ditches, or at trenches lined with permeable materials. Similarly, when the soil is frozen, any runoff will move above the frost layer and primarily be shed from the land. In heavy clay and frozen conditions, a large proportion of rainfall or snow melt can be expected to be shed from the land.

In summary, in the Rosser CentrePort Lands the grade of the land is typically very shallow with clayey, low permeability soils underlying the highly organic clay. This means that water trapped in the soil media or moving across the surface travels very slowly, allowing an optimal time for root uptake, evaporation, or deep soil infiltration. Sometimes, however, these processes are too slow for the preferred type of crop and field drainage is required to prevent crop damage. Therefore, the rate of surface runoff in the agricultural lands is frequently augmented by field drains. Typically, between 4 and 10 field drains can be found within each section. The field drains act to increase the rate of runoff from the rate that would be experienced in a natural state. As stated earlier, when the lands are used for agriculture and in an optimal vegetated state, 10% of the rainfall runs off the land. However due to the slow permeability of the deeper clay soil layers, fluctuations to vegetation water uptake, and seasonally frozen conditions, the agricultural land may shed much higher rates and volumes of runoff water during certain times of the year.

Generally, when the land area is used for agricultural processes, the above-noted natural processes results in 90% of the stormwater being managed by the soil and 10% of the rainfall being stored on the land or shed from the land by runoff or drainage routing.

From a drainage management perspective, there are typically two annual peak flows that one must be aware of. This includes spring freshet, when the ground is frozen and a large proportion of the snow melt runs off at a rapid rate. The second peak occurs as a result of heavy rainfall. Previous studies have demonstrated that the runoff rate from a statistical summer rainfall event is more significant than the runoff from a statistical snow pack melt. In addition to this, climate change is resulting in an increased statistical rainfall intensity and a decreased snow pack. Therefore, this report recommends the use of statistical rainfall for drainage designs.

With increased rainfall in winter months and an increased peak rainfall intensity, drains and channels may be plugged with ice or backwatered. It is therefore imperative that detention areas have the capacity to hold a conservative amount of rainfall or snowmelt water, this will avoid damage to infrastructure and structures while the blockage is removed. Hydraulic models could be conducted to confirm the risks and associated flood protection levels that are required to prevent backwater impacts.

3.3 INFLUENCE OF SURFACE MATERIAL TYPE – POST DEVELOPMENT

When land is subdivided into smaller parcels and transected by roads and structures, the opportunity for vegetative uptake, absorption into the organic soil, and evaporation is reduced according to the percentage of land that is covered by impermeable materials. Moreover, because of the trenches and cuts in the organic soil layers, the time of transportation is functionally reduced, which then reduces the timeframe available for natural processes. Within the Rosser CentrePort Lands, the amount and velocity of runoff will vary depending on the density of the buildings, roads, and construction material types. Figure 3, below, demonstrates how increasing the impermeable ground cover due to the density of construction also increases the stormwater movement and runoff volume.

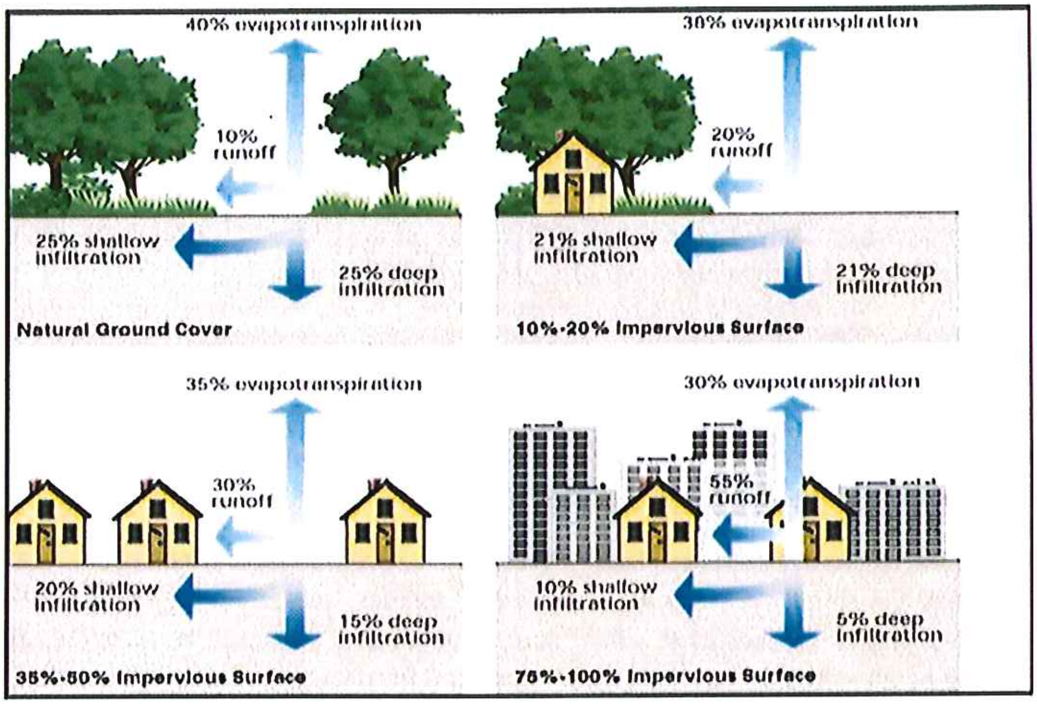


Figure 3 - Land Use Changes and the Hydrologic Cycle (US EPS, 2007)

Less-permeable surface materials (such as packed gravel, asphalt, concrete, and roofing materials) have a low surface roughness that permits the water to move off the surface in a shorter duration and with higher velocities than would occur if the land remained in a natural state or was used for agricultural purposes. When the higher velocity water reaches the ditches and waterway channels, it continues at a higher level, thereby impacting the banks and flood plains.

Post-development runoff in the Rosser CentrePort Lands will depend on the designated land use type. For convenience, the land use map and suggested runoff coefficients listed by land use designation are attached to this report. In the small lots within the Industrial Centre area, it is anticipated that buildings will typically cover 50% of the lot (but may cover as much as 90%), while most of the remaining lot area will be covered by pavement. If the lot grade plan includes swales and frontage landscaping, then approximately 10% of the land will be permeable and of that, only a small percentage of the water will infiltrate deeply into the soils. In this situation, unless control measures are applied, approximately 80% of the rainfall water will run off the lot into the drains. Likewise, the total subdivision area including the roads, ditches, and walkways will shed approximately 80% of the rainfall.

In the larger Industrial General area and Industrial Heavy area, it is anticipated that lot owners will choose a mix of gravel and asphalt or concrete paved surfacing materials, and buildings will cover less of the lot areas. Under the Manitoba Regulation 48/2016, the maximum permissible site coverage is 70%, however typical development thus far has demonstrated an average lot coverage of 40% by buildings. Side lot swales and frontage landscaping are also anticipated.

Asphalt and roof material offers 0% infiltration and 5% evaporation, which means 95% of the stormwater will run off from these materials. Gravel, especially when placed on a thick rock-base with larger void spaces, offers an element of water detention in the interstitial and void spaces. Moreover, because of the roughness of the surface, the travel time of runoff from gravel is double that of runoff from a concrete or asphalt surface or rooftop. Finally, due to the size of the lots, excavations for roads and ditches will occur less frequently when compared to the smaller lots anticipated in the Industrial Centre area. In the Industrial General area and Industrial Heavy area, it is anticipated that approximately 70% of the rainfall will run off the lots, and the total subdivision area including the roads and ditches will shed 70% of the rainfall.

Rail yard and rail right-of-way development is anticipated to occur in a significant portion of the Rosser CentrePort Lands. Typically, structures, asphalt areas, and rail lines cover less than 20% of lands designated as rail use, with the remaining 80% of the rail-use lands being surfaced with aggregate or gravel. It is anticipated that, without stormwater management, the rail use areas would shed 70% to 80% of the rainfall that falls upon the land.

The other visionary land use in the Rosser CentrePort Lands is recreational or green space. Many recreational facilities are already in place and include golf courses, soccer pitches, nature trails, treed areas, native prairie grasses, and other natural vegetated areas. It is expected that additional area will be allocated as green space or developed for outdoor recreational use during the overall development of the Rosser CentrePort Lands. Under the existing land use, it was found that these areas are 80% to 95% trimmed lawn grass, with the remaining 5% to 20% of the land cover being natural. As a recreational use area, the topsoil is compacted, vegetation is short, and the grade is low or natural. Recreational areas are typically shedding 30% of the rainfall runoff.

As can be deduced, stormwater runoff rates, velocities, and water pollutants increase with development, yet the receiving systems and water bodies are expected to remain un-impacted. Yet, without mitigative measures, the conversion of agricultural land to industrial land use substantially increases the runoff volume, velocity, and transports contaminants. Secondly, by the conversion of land use, municipal drainage systems and local drains are strained with the increased pressure of higher velocities and shorter-duration, higher-flow events. Moreover, contaminated water can impact municipal structures by causing corrosion of metal culverts and creating sediment dams in ditches. Finally, the natural downstream water bodies that receive the runoff are expected to remain within the existing natural hydraulic regime and water quality parameters.

> The routing of post-development runoff can result in an increased flow and increased contaminant transport into lakes and streams. Without mitigative control, the conversion of agricultural land to developed land impacts the lakes and streams by increasing the peak water levels, increasing channel velocities, and introducing contaminants.

Figure 4: Protecting Our Water Resources for Downstream and Future Needs is Essential

3.4 INFLUENCE OF ANTECEDENT CONDITIONS

Antecedent conditions, that is, the readiness of a material to accept water within the void spaces, is dependent on the amount of water received previously and the material's ability to disassociate from that water. The source of water dropped onto the soil or surface material may be introduced by human uses such as sump pumps, irrigation, and downspouts, or natural rainfall. Antecedent conditions are an important consideration when predicting and evaluating runoff from natural land, as the natural land has a buffering capacity. Runoff from hard surfacing materials (such as asphalt and concrete) is not impacted by antecedent conditions. However, dry wells and dry river beds, stormwater detention and retention ponds, and municipal ditches are influenced by the antecedent conditions.

As the regulator and manager of drainage, it is important to be aware of the antecedent conditions of the system when considering flood risks and drainage needs. That is, a spring runoff following a wet autumn will result in a higher peak runoff. Likewise, sustained rainfall over several weeks results in an above normal rainfall accumulation that will raise the detention pond levels and reduce the buffering capacity for future near-term events. As indicated by climate change reports, multi-day events that include high intensity events are occurring more often. Therefore, it is important to be cognizant of the increasing risk and plan to mitigate this through the use of stormwater management planning.

4 MANAGEMENT OF STORMWATER

To ensure the sustainability of the region and to prevent downstream impacts, it is imperative that watershed is preserved post-development. This includes the control of runoff volumes, flow velocities, and water quality, plus management of the groundwater. The following sections address methods of stormwater management.

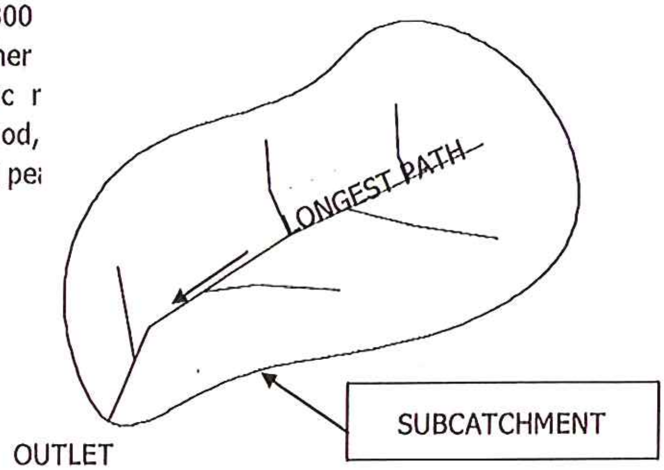
4.1 STORMWATER MODELING TECHNIQUES

Sustainable development and surface water management involves the quantification of stormwater runoff. With reliable flow information, all parties can accurately design stormwater channels and detention areas to accommodate the volume of water that is expected to be shed from the land during specific statistical events. Moreover, by predicting the runoff for different land use modifications, one can assess what mitigative measures are required to manage the runoff.

There are many methods of predicting stormwater runoff. Some methods include: hand calculations, routing routines (typically calculated in spreadsheets), charts, hydrographs, and software modeling. For most developments that are anticipated in Rosser, sophisticated techniques using software modeling is not required.

A simple method for calculating the stormwater runoff is to complete a hydrological analysis using the Rational Method or the Modified Rational Methoc accuracy for a study area less than 121 hectares (300 developments (especially involving piped flow), other Rational Method, the TR-55 Method or hydraulic r "modified" is an added function of the Rational Method, include a runoff hydrograph (time-based flows) and pe results in only the calculation of the peak flow.

For use of the rational method, each catchment area must be identified and the flow calculated independently. The Rational Method predicts stormwater runoff according to this formula:



$Q = kCIA$

Where:

Q = runoff - flow (m^3/s)

k = a conversion factor, 1/360 for basic metric units

C = unitless runoff coefficient

I = rainfall intensity (mm/hr)

A = area (hectares)

The runoff coefficient, C, very closely predicts the proportion of rainfall that is shed from the land with various surfacing types. In areas with multiple surface types within one water collection area, a weighted C-value may be approximated.

$$C(weighted) = \frac{\sum(C_1A_1 + C_2A_2 + \cdots C_zA_z)}{\sum(A_1 + A_2 + \cdots A_z)}$$

Where

$A_{1,2,\ldots z}$ = surface area of each material type

Table 1 is a chart of typical runoff coefficients and environmental impact factors listed by land use. This chart is applicable to the fine grained lacustrine clays on shallow graded land with normal antecedent conditions and for a 5% event.

Table 1: Runoff Characteristics by Surface Material Type

Surfacing Material	Rational Method Runoff Coefficient
Annual Crops	0.20
Perineal Crops	0.12
Lawn Grass	0.25
Gravel	0.50
Asphalt Road / Parking Lot	0.95
Concrete Road / Parking Lot	0.95
Roof	0.95

The rainfall intensity, I, may be computed from a statistical analysis of historical data with consideration for the time of concentration. A 30-year+ history of data that is recorded at a location of a nearby station that experiences similar weather conditions is preferred.

The Rosser CentrePort Lands experiences rainfall characterized and reported at the Environment Canada Hanger Line Road Climatic Station, ID 5023224. The appendicized station information and rainfall intensity duration curves include 49 years of historic data. Although the statistical analysis of the data was updated in 2014, the historical data period ends in 1996, and therefore could benefit from an updated analysis to confirm any change to the statistical trends. However, it is anticipated that any deviation from the curves would have minimal impact on a pre- and post-development Rational Method flow analysis.

The time of concentration, Tc, reflects the time required for a particle of water to move from the farthest point of the study area to the outlet of a subcatchment area. For the rational method, Tc is the time of peak discharge and is calculated on a catchment area basis. The time of concentration disaggregates into sheet flow, shallow concentrated flow, and channelized flow.

Sheet flow is the first method of water movement across the ground surface. This typically occurs for 30 m or less in an unpaved area and 90 m or less in a paved area. The travel time for sheet flow is based on the Manning's kinematic equation. Here, travel time is dependent upon Manning's n, slope, rainfall, and the distance traveled, in accordance with the equation below:

$$T(sheet\ flow) = \frac{0.091x\ L^{0.8}x\ n^{0.8}}{P2^{0.5}\ x\ S^{0.4}}$$

Where:

T = travel time (min)

D = distance (m)

n = Manning's n for floodplains (unitless)

S = slope (m/m)

P2 = 2-year 24-hour rainfall accumulation (mm)

Table 2: Typical Manning's n-values for Floodplains

Floodplains	
a. Pasture, no brush	
1. short grass	0.03
2. high grass	0.035
b. Cultivated areas	
1. no crop	0.03
2. mature row crops	0.035
3. mature field crops	0.04
c. Brush	
1. scattered brush, heavy weeds	0.05
2. light brush and trees, in summer	0.06
d. Trees	
dense willows, summer, straight	0.15

The second method of water movement is through shallow concentrated flow. The time for shallow concentrated flow may be calculated by dividing the length of shallow concentrated flow by the velocity of the flow.

$$T(conc\ flow) = \frac{L}{\frac{60}{10\ x\ 0.073\ x\ \sqrt{S}}}$$

Where

T = time of concentrated flow (min)

S = slope (m/m)

L = length of concentrated flow path (m)

The final method that water moves from the land is frequently within developed channels such as swales and ditches. The time of channel flow may be calculated by Manning's Equation for Open Channel Flow. This is as follows:

$$T(open\ channel) = \frac{L}{60\ x\ V}$$

$$V = \frac{Q}{A}$$

$$Q = \frac{1.0}{n} A(R^{\frac{2}{3}})(S^{\frac{1}{2}})$$

$$R = \frac{A}{P}$$

Where

T = travel time for channel flow (min)

Q = channel flow rate (m^3/s)

V = average velocity of flow (m/s)

R = hydraulic radius of the channel (= A/P) (m)

A = channel cross-sectional area (m^2)

P = wetted perimeter of channel (m)

S = channel bottom slope (dimensionless)

n = Manning's roughness coefficient for open channel flow (dimensionless)

L = length of flow path (m)

Table 3: Typical Manning's n-values for Open Channel Flow (Chow, 1959)

1. Main Channels	
a. clean, straight, full stage, no rifts or deep pools	0.03
b. same as above, but more stones and weeds	0.035
c. clean, winding, some pools and shoals	0.04
d. same as above, but some weeds and stones	0.045
e. same as "d" with more stones	0.05
f. cobbles and boulders	0.06

f. sluggish reaches, weedy, deep pools	0.07
g. with heavy stand of timber and underbrush	0.1

The total travel time for a subcatchment area, Tc, is then:

$$T(total\ time) = T(sheet\ flow) + T(shallow\ conc.) + T(channel\ flow)$$

In some instances, travel time will also include piped flow, which is a common technique for the control of stormwater runoff peak flows. Use of the below-noted formula aids the designer in throttling the outflow to the permitted peak volume. Piped flow, as it relates to regulating the peak flow, is calculated by the Manning's Formula for full pipe flow:

$$Q(pipe) = \frac{1}{n} x \left(\frac{\pi}{4} x \left(\frac{\emptyset}{1000}\right)^2\right) x \left(\frac{\emptyset}{4000}\right)^{\frac{2}{3}} x\ S^{\frac{1}{2}}\ x\ 1000$$

Where

Q = piped flow (L/s)

n = Manning's coefficient for pipe material (dimensionless)

ø = pipe diameter (mm)

S = pipe slope (m/m)

Table 4: Typical Manning's n-values for Pipe Flow

Corrugated metal pipe (cmp)	0.024
High density polyurethane (HDPE)	0.012
Polyvinylchloride (PVC)	0.011
Concrete (Conc.)	0.011

Using the Rational Method for pre- and post-development characteristics leads the designer to two sets of flows and event times. It is preferred that development areas limit the shedding of surface water to avoid downstream impacts. The designer has several choices to reduce the shedding of water from the planned development site; that is, they may retain the water or detain the water.

Detaining stormwater causes the same volume of water to leave the land, but at a more controlled rate. This is where creative methods that route stormwater through orifices or small pipes, or increase the surface roughness have great influences. The second method, water retention, involves keeping the water with evaporation, transpiration, or infiltration being the primary method of surface water removal. Please note that permanently wet ponds (retention ponds) are not permitted (as described in the proceeding sections) however vegetation, rain gardens, dry wells, and other biological remedies would be acceptable.

Studies have also shown that techniques such as the TR-55 method further improve the quantification of the time of peak flow. By properly quantifying the time of peak flow, the volume of runoff that must be stored or detained may be altered. On this basis, the TR-55 method and hydraulic routing models are preferred for complex designs of areas encompassing more than ten lots or for development areas larger than 4 hectares (10 acres).

A proper quantification of the peak flow, time of peak flow, and total volume of runoff are essential for the management of stormwater runoff from a municipal perspective. The volume of water that is permitted to flow from the land must be managed within the capacity of the municipal and provincial drainage systems. Note that by designing to a specific control level (i.e. the 1:50 year event) the area will not be protected from higher level events. Moreover, the Standards that are set today and implemented over subsequent years must consider changes to precipitation and temperature that may result due to climate change. Therefore, when designing, it is imperative to consider the correct amount of storage capacity.

The Prairie Climate Centre, a joint venture between the University of Winnipeg and the Institute of Sustainable Development is studying the long term changes to weather in this region. A model of the RM of Rosser area was completed and the results are included in the appendix of this report. Model results indicate generally increased temperatures in the summer and winter months, plus increased rainfall throughout most months of the year. Further information about the Centre's studies is available at: www.prairieclimatecentre.ca.

For the Rosser CentrePort Lands area, at the lot or subdivision level, a design event size should be no less than one hour, and managing the 1:50 year post-development outflow to a 1:5 year pre-development runoff rate provides outflow regulation consistent with the capacity of the municipal infrastructure. Similarly, an outflow-controlled area must have the capacity to temporarily store the 1:50 year volume of water for a 3-hour storm duration that would otherwise be shed at the uncontrolled flow rate. Stormwater controls must be designed on the subdivision lands; proposed road side ditches should not be used for stormwater storage.

Where a lot is part of a subdivision that includes stormwater management (on or off the lots), the lot developer is not required to add additional stormwater management controls, however the lot developer must adhere to the design constraints for which the subdivision was planned and stormwater controls that are in place on the lot must remain intact.

Where a lot is being developed and no stormwater controls are in place or the existing controls do not adequately manage the water from the proposed lot development, the lot must be designed to control the stormwater, as noted above.

To aid in the design process, the stormwater management requirements are included in Standards and checklist formats. The documents are included in the appendix of this report.

4.2 RECOMMENDED WATER QUALITY AND GROUNDWATER MANAGEMENT TECHNIQUES

To develop the area in a sustainable way, management of water quality above and within the ground are important planning considerations. Moreover, groundwater recharge zones must be preserved and protected from contamination.

Rosser is committed to water quality protection and as such, is currently developing Sewer and Land Drainage Standards as part of the planned Local Improvement By-law. The Rosser Sewer and Land Drainage Standards are applicable to all forms of discharge including stormwater runoff, snow melt, sump discharge, washing, dewatering, industrial process water, steam, etcetera, regardless of whether it is discharged into a land drainage pipe, ejected over a surface, flows into a drain or creek, or otherwise leaves the property.

The intent of the Standards with respect to land drainage is to clarify permitted and non-permitted discharged chemicals, compounds, and sediment; set maximum permitted concentrations and temperatures; and regulate the permitted rate and volume of water that may be discharged from a site during winter months.

Because the Rosser CentrePort Lands drains into either creeks and rivers or Winnipeg's land drainage system, it is intended that the Rosser Sewer and Land Drainage Standards will be as stringent as the Manitoba Water Quality Standards, Objectives, and Guidelines under the Water Protection Act and the City of Winnipeg Sewer By-law. In some cases, a Pollution Prevention Program may be required prior to the approval of a development.

For industrial developments, a Pollution Prevention Program and compliance with the Rosser Sewer and Land Drainage Standards will assure that water quality is maintained while protecting infrastructure and downstream natural resources. Surface water runoff from storms and snow melt may also contain deleterious substances, and as this is an issue that all lot owners must attend to, additional design and management recommendations are provided below.

Canopy interception, detention, diversion, and biofiltration of the rainfall and snow melt runoff can improve the water quality, allow infiltration into the soil, and reduce the peak runoff. One excellent example of a project that utilized many water management techniques is the Gaynor Family Library, in Selkirk, Manitoba. A short study of the library site design was conducted and is included in the Appendices of this report.

Some ideas for on-lot runoff water quality improvements and groundwater infiltration include:

- Encourage aeration in channels through the use of cobble beds and drop structures.
- Create depressions in channels where sediment and suspended solids can settle out.
- Use meanders and vegetation to slow the runoff velocity and reduce the potential for erosion of a channel.
- Vegetate water pathways with nutrient-absorbing plant species such as sedges and reeds. To reduce nutrient transport from the site, remove the dead stalks and dead foliage in the early autumn, where possible.
- Plant trees along the top of the slopes of channels to cool the runoff and absorb water. Do not plant trees within the drainage path as they will impede flow.
- Consider the use of temporary mechanical silt barriers and velocity control measures for the period while semi-aquatic and aquatic plants are establishing.
- Design paths for rainfall runoff from roofs and clean surfaces to avoid transport across contaminated pavement.
- Install permeable paving and infiltration chambers.
- Create landscaped areas with low maintenance vegetation instead of turf grass, and design the paving to flow off the asphalt into the landscape area instead of finishing asphalt areas with curbs and gutters.
- Plant deciduous trees with large canopies and coniferous trees with wide branches to maximize rainfall canopy interception opportunities.

4.3 MANITOBA INFRASTRUCTURE DRAINAGE DESIGN REQUIREMENTS

The and auxiliary roads are closely networked with the Manitoba Infrastructure (MI) roads and road infrastructure. Along with the roads, MI also operates and maintains recognized Provincial Drains, such as sections of Omand's Creek and Sturgeon Creek.

Within the role of planning intermodal vehicular transportation, MI designs provide for adequate drainage away from the roadway infrastructure. The MI drainage designs provide elements of safety and aid in the infrastructure's long-term stability. In many locations, MI right-of-ways (ROW) flank the Rosser CentrePort Lands and collect surface water runoff directly from the Development Area. In other locations, the Development Area and MI drainage networks are connected at road intersections, such as a roadside ditch that drains into a highway ditch. Finally, in some instances lots drain into private drains which then connect to Provincial (MI) Drains.

MI has established Policies for the construction of works that impact MI ROW's. Typically, through-grade crossings in a provincial trunk highway are designed to accommodate the pre-development 1:50 year (2%) statistical event, while any intersection crossings must pass the pre-development 1:33 year (3%) event. With respect to direct runoff from lots into MI ROW's, 1:20 year (5%) post-development flows must be restricted to the 1:20 year (5%) pre-development flows. Any flow rate or velocity in excess of the above-noted design criteria must be controlled upstream of the MI ROW. The full policy is appended to this drainage report.

With respect to the Provincial Drains, any planned changes to water regime upstream of the Provincial Drain must be communicated to the Water Management and Structures Division (Operations and Maintenance Section) at MI. An open dialog between parties will ensure that upstream and downstream plans are developed in the correct sequence, and that there is no negative impact to the overall drain system as a result of changes.

It has been recognized that some sections of the regional drains are currently privately owned, but could benefit from the ongoing maintenance by the local drainage authority. This is specifically relevant to the portions of Omand's Creek and East Colony Creek which are within the Rosser CentrePort Lands. It is recommended that the creeks, flood plains, and 10 m (30 ft) riparian buffers are transferred to the government through a future subdivision process.

4.3.1 DRAINAGE AND WATER CONTROL LICENSING BRANCH DRAINAGE LICENCE

The Manitoba Sustainable Development Drainage and Water Control Licensing Section requires that developers acquire a drainage license for any development that impacts the natural course or existing course of surface water runoff. This license is required for new drainage routes and maintenance of existing drainage channels.

If a subdivision involves 10 or more 0.8 hectare (2 acre) lots, for a total of 8 hectares (20 acres) or more, stringent drainage control measures must be applied. In these situations, the drainage design must meet the:

- Subdivision development drainage plan requirements, and
- MI ROW drainage policy, if the stormwater runoff is directed towards MI ROW's.

The subdivision development drainage plan requirements include the control of the 1:50-year post-development event flow rate to a 1:5-year pre-development event flow rate, among other criteria.

Where less than 8 hectares (20 acres) of land is impacted, a developer must still implement accepted engineering Standards with respect to drainage design, construction of drainage works, and ongoing maintenance.

The MI subdivision development drainage plan requirements and MI ROW drainage policy are appended to this drainage report.

4.4 CITY OF WINNIPEG DRAINAGE DESIGN REQUIREMENTS

The City of Winnipeg (Winnipeg) lies to the east and south of the Rosser CentrePort Lands. The City's Plans and Strategies such as: OurWinnipeg Plan By-law No. 67/2010, A Sustainable Winnipeg Direction Strategy, and Complete Communities Direction Strategy - Secondary Plan No. 68/2010, describe potential expansion of residential, industrial, and commercial land uses.

Moreover, existing nearby development includes residential, commercial, manufacturing, and industrial use areas, which challenge the drainage systems in the same ways that the Inland Port Special Planning Area Development Plan projected development will challenge the drainage systems without appropriate design and adherence to applicable land drainage design requirements.

Winnipeg abuts the Rosser CentrePort Lands (sometimes separated by MI ROW) to the east and south and drainage channels which traverse through Rosser CentrePort Lands are conveyed through Winnipeg after collecting the runoff from the Rosser CentrePort Lands. Omand's Creek, the Truro Creek watershed, and the City Protection Drain are important collection areas that must be considered when developing in the region. Maps, which are appended to this report, clarify the water collection areas.

The City has recently undertaken works to improve the riparian areas and mitigate erosion of the creeks and drains downstream of the Rosser CentrePort Lands. These creeks and drains then flow into larger drainage systems such as the Assiniboine River to the south, and the Red River to the east. Both river systems are carefully managed by agreement between the Province and the City to mitigate flooding, bank instability, and erosion.

Within Winnipeg, the Water and Waste Department (Winnipeg's drainage authority), stipulates the maximum peak flow and depth of ponding on any commercial or industrial development area or flat rooftop larger than 1,000 m^2 (10,750 ft^2). The full criteria for lot drainage and grading are documented on the City website and within the Lot Grading By-law. With respect to typical commercial developments, the City provides a maximum C-value for each prospective development area, for which the design engineer must control the 25-year post-development event runoff to a 5-year pre-development event runoff, with the maximum depth of ponding to be 0.3 m on a paved driving surface. For the calculation of retained stormwater volume in a typical situation, the Isochrone Method is preferred. This method is described in the MacLaren Manual, 1974. For larger development areas, the City requires an analysis of a 1:100 year event or the May 2010 event. The City requires hydraulic modeling for complex situations.

Essentially, the Isochrone Method considers the runoff hydrograph to be a triangle shape. The Isochrone Method is not recommended for larger areas that are designed with a more complex storm water system including retention or detention ponds.

The City has calculated the maximum runoff coefficient, C, or unit release rate, for the areas based on the capacity of the drainage system. In the City, this is highly effective as the drainage system was developed over a long period of time and includes existing ponds, stormwater pipes, and open ditches. By asking a developer to reduce the post-development flow to a smaller sized pre-development flow, the City is then able to improve the overall drainage management for a region depending upon the capacity of that portion of the system.

Over time, since the publication of the MacLaren Manual, methods of hydraulic routing have been refined and proven. It has been found that as the land mass increases, the Isochrone Method overestimates the true storage volume requirements. Moreover, in complex systems, i.e. involving ponds, pipes, and rooftop storage, routing models are preferred.

The development lots within Winnipeg are typically smaller dimensions than the lots expected in the Rosser CentrePort Lands, therefore, the application of the Isochrone Method would overestimate storage requirements. Moreover, the regulatory prescriptive C-value method would not be recommended for the Rosser CentrePort Lands as the drainage system is uniform throughout the area. Finally, the open ditches and Provincial Drains within the Rosser CentrePort Lands provides an additional peak flow capacity that is not available in the City's piped stormwater areas.

There are two considerations to deduce from this summary of Winnipeg drainage criteria. Firstly, it is imperative that any changes to surface water runoff volume onto the City lands, or changes to the hydraulics of the drains, are discussed and agreed upon by all associated parties. Secondly, although Winnipeg drainage criteria are effective for typical development on City lands, the Isochrone Method would not be appropriate for Rosser CentrePort Lands, and therefore, a different method of runoff management is recommended.

Along with Winnipeg's stormwater management policies, Winnipeg also has controls for water quality preservation for water that leaves the lots. This includes disposal through the land drainage pipe network or into ditches, swales, rivers and lakes. The City has developed Standards for construction requirements, discharge quantity and concentration, spill response, pollution prevention planning, and other control items. Specific details of the City's measures are included in the City of Winnipeg Sewer By-Law No. 92/2010.

In addition to the Sewer By-Law, Winnipeg has guidelines that are aimed to avoid the impacts from the Greater Canada Goose populations and other migratory fowl by discouraging the birds' use of areas. Generally, the City recommends that surface ponds are designed to be naturalized along the shorelines through the establishment of emergent vegetation followed by natural prairie grasses in the uplands. Naturalization of ponds makes it more difficult for young fowl to reach the ponds, and therefore nesting and rearing has been found to occur more frequently at conventional ponds or at bare ramps which provide vehicular access to the naturalized ponds. However, the City has found that nesting geese can establish anywhere that has standing vegetation (may be dead vegetation from the previous year), access to water, and at locations that are first to show exposed ground in spring (i.e. adjacent to buildings).

The City has also found that migratory goose populations are greater in ponds that are in close proximity to some types of agricultural fields. At naturalized and conventional ponds, it is typical for large numbers of geese to be in flight in the evenings as they spend the day feeding in the nearby fields or resting in the short grass adjacent to the conventional ponds, and then the geese spend the evenings resting on the ponds. Naturalized ponds do not typically host geese in adjacent tall grasses. The creation of naturalized ponds is not required by City Standards; however, naturalized pond designs are encouraged due to their socio and environmental benefits.

It is acknowledged that the Rosser CentrePort Lands will not include the development of constantly-wet retention ponds, however, some measures are recommended to prevent migratory birds from using detention ponds, green spaces, and ditches. Recommendations are as follows:

- Remove vegetation from ditches at the end of the season.
- Maintain ditch bottoms to avoid standing water and ponding.
- Encourage the development of naturalized areas adjacent to existing and proposed creeks, drains, and detention ponds.
- Avoid developing mowed ramps adjacent to detention ponds and water bodies.
- Use rock and woody material to create rough landscaping features adjacent to water bodies.
- Install natural upland vegetation and tall standing grasses as an alternative to Kentucky Blue Grass.
- Plant (and encourage the planting) of perennial crops or non-cereal annual crops in agricultural fields adjacent to the developed areas.

4.5 WINNIPEG AIRPORT AUTHORITY DRAINAGE DESIGN REQUIREMENTS

The Winnipeg Airport Authority has one drainage criteria with respect to standing water within the aviation zone. Because the Rosser CentrePort Lands are in close proximity to the airport, it is imperative that the Municipality adhere to the Winnipeg Airport Authority's (WAA) policy of limiting standing water. This policy was set in place to discourage the flocking of migratory birds within the designated aviation flight paths.

The Winnipeg Airport area is naturally and purposefully designed with a low grade for aviation and ground transport purposes; however, this results in drainage challenges. The airport sub-surface soils are frequently saturated and contain a high groundwater level. Interception of rainfall runoff before it reaches the airport land is essential for ensuring the operation and maintenance of the airport. Maximizing rainfall dispersion through canopy interception, root uptake, and evaporation are the preferred methods for lands near to the airport as these methods will also minimize the soil saturation.

The Winnipeg Airport Authority concurs with other regulatory bodies regarding the regulatory control and management of stormwater runoff. Some options for consideration include:

- The establishment of Lot Grading and Stormwater Management Standards,
- Improvements to the municipal drainage networks, and
- Developing stormwater detention areas (occasionally wet areas that discourage the establishment of migratory birds).

5 SNOWPACK AND SPRING FLOODING

The peak annual channel discharge and maximum risk for overland flooding frequently occurs during spring freshet, that is, as the snow melts. This is especially true in natural areas with large catchments and higher order drains. In smaller drains and in built up areas, however, a high-intensity summer rainfall event may be equally challenging to manage.

Lot owners who are planning to develop sustainably, shall plan for snow clearing and summer stormwater runoff. These two management plans will sufficiently address the on-lot drainage requirements. That is, higher statistical volumes of snowpack are adequately represented over small areas through the study and accommodation of stormwater runoff.

As the Rosser CentrePort Lands are developed into commercial and industrial use areas, it is anticipated that the lots will be cleared of snow. If the snow is moved to collective snow dump areas, the spring runoff within the development will be reduced accordingly. Alternatively, some lot owners may opt to store snow on the lot. It is notable to mention that the collected post-development snow will contain suspended sediment and bonded particles that are less favorable for transport within the natural streams. Therefore, permitting the melting to occur in a controlled area and not directly into streams will allow time attenuation for settlement and separation of the associated particles.

On-lot storage of snow is a permissible activity, with the following guidelines:

- Snow piles shall not obstruct fire protection access routes (allow the required clearance on all sides of a building) – refer to the Fire Commissioner for additional regulations.
- Snow piles shall not obstruct lot drainage nor encroach into ditches, swales, or culverts.
- Snow cannot be piled or pushed into the municipal right-of-way.
- Snow cannot be permitted to accumulate (or piled) over municipal structures including fire hydrants, well casings, water flush outs, etc.
- Snow piles, when melting, cannot drain towards foundations nor directly into municipal or provincial drains (drainage into side yard swales is permitted).
- It is recommended that a curb or berm be constructed around planned snow pile areas.
- Planned drainage from snow piles shall be carefully considered by the lot owner and remains the risk of the lot owner.
- If the snow piles melt into a detention pond, the melt cannot exceed the design capacity of the detention pond.
- Melt water from snow piles must comply with water quality requirements, as set forth by the Municipality, City of Winnipeg, and the Province.
- Snow pile locations should be shown on drainage plans.

When safely planned for, snow piles and accumulated snow do not increase the capacity requirements for municipal drainage channels. Again, a high-intensity summer rainfall event may introduce an equally high water level in ditches and in floodplains, and therefore, municipal drainage may be designed for the conveyance of high-intensity summer events.

Some post-development items for municipal maintenance consideration include:

- Increased traffic and paved areas raise the temperature of the surfaces and therefore results in more water reaching the ditches during the winter months. Maintenance should verify that ditch structures remain passible and not blocked by ice. Ice removal and culvert steaming may be required.
- Some industrial operations introduce flowing water to the ditches during the winter. Flowing water, if permitted during the winter months, will result in a buildup of ice in the ditch and may block nearby culverts. The Pollution Prevention Program should be discussed and agreed upon prior to the commencement of development.
- Standing water adjacent to roads softens the road shoulder and increases the risk of embankment slumping. Softened road shoulders have a reduced capacity for heavy loads. Frequently, the standing water that occurs in spring may be mitigated by the removal of downstream blockages.

With respect to drainage management, it is deemed sufficient to design the capacity of ditches and drains based upon summer stormwater events. This is because the contributing areas are relatively small: a small area is influenced more by a short-duration intense event than it would be influenced by the convergence of snowmelt-runoff for the overall catchment.

6 EXISTING CONDITIONS AND DRAINAGE CONCERNS

The Rosser CentrePort Lands contain field drains, roadside ditches, municipal drains, and Provincial drains with anecdotal and quantified records of the performance with respect to surface water conveyance. This study assembles and assesses the condition and conveyance potential of the existing municipal drainage systems based on the various records of previous studies, documented overland flooding, and new topographic data.

6.1 DRAINAGE STUDY TOPOGRAPHIC DATA

This drainage study relies upon many sources of data for pre-development, existing, and post-development terrain and hydrological analysis. Sources of topographic data includes:

- Survey data previously collected by Barnes & Duncan Legal Land Surveyors, for the RM of Rosser drain maintenance program,
- Survey data collected by Lankhout Land Surveys and Geomatics, as commissioned by JME for completion of this study,
- Manitoba Lands Initiative, Manitoba Conservation – Geomatics Services; Cadastral Mapping, Drain Digital Data, 2004.
- Manitoba Infrastructure and Transportation, Lidar Data collected in 2010 and 2014.

The above-noted data was used to design ditch and drain profiles, draft road right-of-way cross sections, develop a stormwater management plan, and assess the general overland grading. The compiled data is presented in maps, plans, spreadsheets, and digital files appended to this report.

As the Rosser CentrePort Lands contains more than 45 km^2 (11,000 acres), detailed topographic data is not available for the entire region. Specifically, data gaps occur on privately owned agricultural fields, and on undeveloped right-of-ways. Data will be collected in these areas as the need arises. That is, when a road right-of-way is being designed and installed, or when privately owned land is being considered for subdivision and development.

6.2 MUNICIPAL DITCH PROFILES AND DITCH ASSESSMENT

The topographic data for the municipal ditches was compiled and is presented in Drainage Profile Drawings, which are included with this report. The typical print size of the profiles is 11x17. This topographical data was collected in cross sections (instead of linear profiles), to aid in the calculation of the maximum ditch conveyance and storage capacities. Field inspections of the drains showed that the maximum capacity is currently limited by local grading issues (infilling with topsoil), ditch damage (such as rutting by quads), and aged culverts (buckling and crushed ends).

Many sections of the municipal ditches require cleanout, regrading, and culvert replacement prior to the total development of the Rosser CentrePort Lands area. The ditch maintenance work may be approached from a needs-assessment perspective. That is, commence ditching maintenance work at the downstream end of the regions expected to be developed next. To facilitate the anticipated on-going need for ditch maintenance, it is recommended that a municipal budget line-item be established for the ongoing maintenance and enhancement of the drainage.

As mentioned, to verify the capacity of the ditches, right-of-way cross sections were surveyed. Some cross sections are displayed on the profile drawings, while additional cross sections and survey data are stored in data files for future use. This information is useful for the assessment of potential road embankment failure zones, traffic capacity studies, and roadway improvement analysis.

Based on the survey data, photographs, and field inspections, it was found that there are approximately 8 miles of ditches that require clean out, and 16 additional miles of ditches which require ongoing maintenance within the Rosser CentrePort Lands. From the surveyed ditches 84 culverts were inventoried. Of those culverts, 13 culverts have significant damage or deterioration and require replacement. Replacement of the damaged culverts should occur within the next 5 to 10 years or before any upstream development.

6.3 CULVERT INVENTORY DATA ACCESS THROUGH GOOGLE EARTH PRO

Further to the creation of municipal ditch profiles, this study also includes a culvert inventory to aid in the maintenance and replacement of existing culverts. The complete culvert inventory is stored in a *.KMZ file, which is viewable in a GIS software. Quantifiable data is also presented in a spreadsheet and appended with this report.

To access the full culvert inventory in the *.KMZ file, the user must install a GIS program. The simplest solution is to install Google Earth Pro, which is now free for all types of users including consultants, municipalities, and regulators.

The link to the free installation files for Google Earth Pro is below:

http://www.google.ca/earth/

When installing the software, each user must enter a software key. The log-in is your email address plus this key: **GEPFREE** – this key may be used for all installs of the software.

After installing the program, the culvert inventory can be imported to Google Earth Pro as follows.

1. Save the culvert inventory files to a network or local drive (one file is lines and a second file is metadata)
2. Start / run the Google Earth Pro software
3. Click on FILE > OPEN > and browse to the culvert inventory files
4. Click OPEN

After following these steps, the culvert inventory will load and Google Earth Pro will scale your window so that you can view the data set. Scrolling in and out will expose more data points and lines, while clicking on the lines and points will bring up the metadata and photos for each of the culverts.

The culvert inventory data files may be used to locate hidden frozen culverts in spring, photographically identify new damage when/if it occurs, and plan for culvert replacements on an as-needed basis.

6.4 MUNICIPAL DRAINS AND CREEKS

Municipal drains and natural creeks accept stormwater from overland runoff, field drains, and municipal ditches. Within the Rosser CentrePort Lands, there are two named creeks including Omand's Creek and East Colony Creek, and three unnamed tributary drains, as shown in the appendices maps and Table of Nearby Waterbodies at the end of this report. In the periphery of the CentrePort Lands, there are additional creeks and drains that convey stormwater from the general region. The peripheral drainage routes and catchment areas include the City Protection Drain and Gamby Drain to the north, Sturgeon Creek to the south-west and Truro Creek to the south. The watershed catchment areas for the drains and creeks are depicted on the maps in the appendix.

6.5 FLOOD RISK AREAS

Even with the implementation of stormwater management on future development lots, the risk of overland flooding remains high in several areas adjacent to Omand's Creek. To discuss the potential for flood impact, the overall area was divided into subcatchments (SC), and the flow patterns were mapped. Some portion of the catchment areas are adjacent to CentrePort are therefore these also mapped. These maps are included in the appendix of this report. The subcatchments and the total land areas within the Rosser CentrePort Lands are as follows:

Table 5: Subcatchments and Land Area

Subcatchment Name	Area (Hectares)
Grassmere Creek North	778
Grassmere Creek South	216
Grassmere Creek East	496
Field Drains	201
East Colony Creek	746
Field Drains and CP Rail	672
Upper Omand's Creek	1026
Lower Omand's Creek	452
Truro Creek	38

It was noted that there is a confluence where the subcatchments labeled Field Drains, East Colony Creek, and Field Drains and CP Rail converge in Section 21 and drop into the upper reach of Omand's Creek over a very short distance. Through the routing of stormwater and spring runoff, the confluence area receives water from three subcatchments simultaneously, yet the channel lacks the capacity to accept the peak of stormwater within the banks of the channel during high-flow events. The problem is exacerbated by the very shallow grade and low channel bank elevations. This results in the overtopping of the banks and local overland flooding. Older orthographic images and soil studies indicate that this area has a history as a wetted area.

With new development planned for the upper reach of Omand's Creek, unless the peak runoff is controlled, the upper reach of Omand's Creek will be subject to increased levels of flooding. With development occurring in the contributing sub-basin areas north of Omand's Creek, even with controlled outflow rates, Omand's Creek will experience an increased amount of water. That is, areas along the creek which were occasionally wet will be wet more frequently post-development.

The increased water is expected to reach the creek because the soil within the sub-basin will no longer be absorbing, transpiring, or evaporating the stormwater.

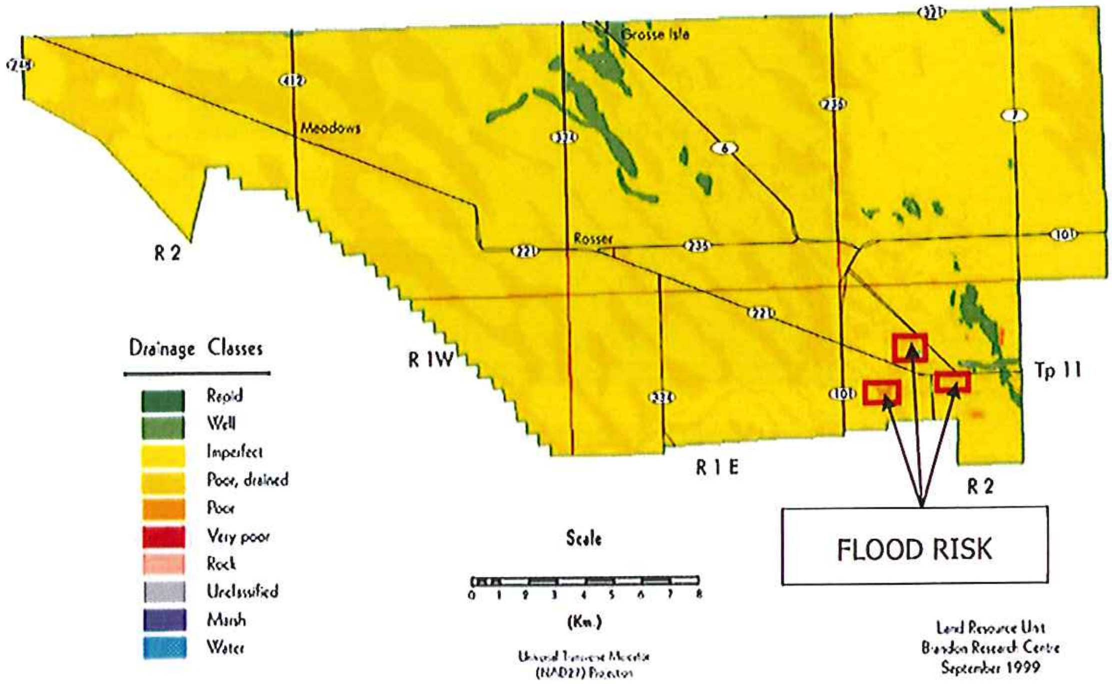


Figure 5: Flood Risk Areas (See Appendix Maps for Detailed View)

To mitigate the flood risks, it is recommended that areas which are prone to flooding (as shown in the appendix maps) be transferred to regulatory control and stormwater detention ponds - that maximize the detention capacity - be constructed therein. The stormwater detention ponds should be designed to mimic natural occasionally wet marsh lands, thereby offering groundwater recharge, plus sediment trapping and nutrient removal which will improve the water quality.

Please note that further study is required to delineate the exact extent of the flood-prone areas. Some of the noted land may be used for lot development if the flood risk is managed.

One additional mitigable risk area is identified at the north quarter-section between Sections 33 and 34, as shown in Figure 6. In this area, the ditch grades to a low point and then travels overland across private property. This is a natural drainage path, and as such it is recommended that the land owner or potential developer plan for development in such a way that the natural drainage is not impeded and development may occur safely. It would be prudent for the Municipality to ensure that any newly defined drainage channels are protected through easements or land transfers to ensure the long-term preservation and maintenance of the drain.

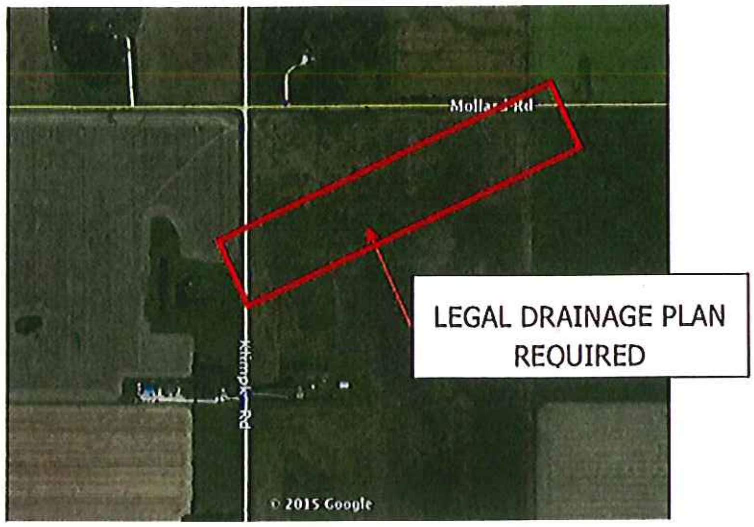


Figure 6: Drainage Plan Required

In addition to the sub-basin catchment areas that are identified within the Rosser CentrePort Lands, there is additional land north, west, and south of the study area which are contributing to the volume of runoff which must be managed. Quantification of the runoff from the additional land and any land use changes is not part of this study. However, it is hoped that global sustainability Policies and good communication between adjacent stakeholders will ensure that negative impacts to drainage due to external factors are not experienced within the study area.

6.6 MAINTENANCE OF THE NATURAL CREEKS

As mentioned previously, the Rosser CentrePort Lands include several natural creeks which shall be preserved throughout the development phases. Management techniques that focus on the protection of the wildlife, fish, and the habitat should be implemented.

Some implementation ideas for maintaining the flow and water quality of natural creeks are as follows:

- Manage the peak flow discharged from developed sites by designing to the Rosser Drainage Standards.
- Prevent sediment transport during construction through the use of silt curtains, straw rolls, hydroseeding, and erosion control matting.
- Prevent sediment transport to streams and drains (ongoing) through the installation and maintenance of vegetative buffers, increased surface roughness, and channeling runoff through detention or settling ponds.
- Develop parklands and walking trails with informative signage alongside streams and drains to create awareness and to create riparian buffer areas.
- Control deleterious material transport at the source – abide by water quality objectives and local Standards.

6.7 PREVIOUS STUDIES

There are many relevant reports that have been generated by others that touch on the study area and provide scientific background information with respect to drainage and water quality. These reports include the topics of geological formations, soils, groundwater water, and surface water hydraulics. The scientific reports are noted in the Reference Section herein. Existing engineering reports that deduce impacts within the Rosser CentrePort Lands typically consist of hydraulic models and hydraulic studies, as described below.

6.7.1 PREVIOUS SURFACE STUDIES

Previous hydraulic studies of the sub-basin watershed areas provide an excellent pre-development baseline for understanding existing and potential drainage impacts. Previous studies have also been conducted for limited regions of the general area. The analyses and recommendations of the previous studies are applied herein to develop a cohesive drainage design for the overall area. Specific studies and study areas include:

- Sturgeon Creek Hydrodynamic Model and Economic Study, AECOM, 2009.
- CentrePort Non-Regulatory Area Structure Plan, AECOM, 2015.
- Omand's Creek at PR 221 Proposed Crossing Hydrologic and Hydraulic Assessment, Bruce Harding Consulting Ltd, 2011.

6.7.2 STURGEON CREEK HYDRODYNAMIC MODEL AND ECONOMIC STUDY

The Sturgeon Creek watershed area is a significant collector of rainfall runoff in the Rosser CentrePort Lands. The 2009 AECOM study was undertaken to review the impacts of overland flooding and assess opportunities for mitigative measures.

The Sturgeon Creek study provides several options for flood relief, including potentially re-directing overflow to the Assiniboine River. The 2009 studies provided a cost-benefit ratio related to the diversion of the 1:10 year flood as compared to the existing scenario of overland flooding within the floodplain. In this study, overland flooding results in farmland crop-losses.

Moreover, it is important to note that the AECOM hydrodynamic model of Sturgeon Creek used the existing land-use as an input characteristic of the model. However, with the development of the Rosser CentrePort Lands, ditches, swales, and surface material changes will increase the runoff velocity, peak flow, and total volume of the runoff. There is a risk of increased flooding in the Sturgeon Creek watershed area if controls are not in place to mitigate the runoff changes.

In the AECOM study it was found that the benefit of a potential diversion would be less than 1.0. This is under the assumption that water storage lands are valued at $300/acre. With the adoption of the Inland Port Special Planning Area Development Plan and the revised land use of the Plan Area since the time of the report, it may be of use to review this economic assessment.

Moreover, as climate change continues to increase the severity and frequency of events, it is now common practice to design measures which would control the 1:25 or 1:50 year event. It would be prudent to extend the flood analysis to a larger frequency event (such as the 100 year) and review the economics of the different event frequencies.

The Sturgeon Creek Hydrodynamic Model Study is an important reference for downstream impacts, as most of the Rosser CentrePort Lands drain into Omand's Creek, which eventually joins with Sturgeon Creek. However, the Rosser CentrePort Lands Drainage Study focuses on matching the pre- and post-development runoff, thereby reducing the potential downstream impact on Sturgeon Creek.

6.7.3 CENTREPORT NON-REGULATORY AREA STRUCTURE PLAN

The CentrePort Non-Regulatory Area Structure Plan is currently in progress. It is anticipated that the Plan will meet the socio-economic requirements while planning for the accommodation of the environmental sensitivities of the area. It is recognized therein that post-development flows should not exceed pre-development flows and stormwater detention may be required.

6.7.4 OMAND'S CREEK STUDY

The Omand's Creek watershed study focuses on maintaining the pre-development hydraulic capacity at the CentrePort Canada overpass at Omand's Creek post-development of the overpass and re-alignment of the road. Within the study, it is recognized that the creek at this location is a fish-bearing water body and non-navigable. The hydrologic contributing area is approximately 8.7 km^2, while the watershed area is approximately 13 km^2.

In the Omand's Creek study, the study area is assumed to be flat annually cropped land with tight clay soils. Discharge values for typical events are calculated therein, and republished below:

Table 6: Omand's Creek Flow at P.R. 221 Crossing

Event Magnitude	Omand's Creek Flow at the P.R. 221 Crossing (m^3/s)
50% flood	1.1
20% flood	2.0
10% flood	2.8
3% flood	4.1

* As reported in the Omand's Creek Report, 2011

For the design of the Omand's Creek crossing at P.R. 221, the fisheries Standard of a maximum 3-day delay 10% probability of exceedance discharge (3DQ10) was applied. The analysis estimated the 3DQ10 discharge to be 2.0 m^3/s.

7 RM OF ROSSER BEST MANAGEMENT PRACTICES

In the interest of developing the land sustainably, this drainage study recommends the adoption of best management practices. The practices are divided into three areas of responsibility, which include maintenance and development tasks for developers, the Municipality, and the Province.

7.1 RESPONSIBILITY OF DEVELOPERS

This section provides some helpful information to aid persons interested in developing and subdividing to understand the requirements with respect to drainage.

Future development designs guidelines include:

- As a condition of development, the applicant will be requested to provide a drainage plan that meets the Rosser Drainage Plan Design Standards. The proposed Standards are in the appendix of this report. Among other sustainability requirements, a drainage plan must demonstrate how the 1:50 year post-development runoff rate is controlled to a 1:5 year pre-development runoff rate for a minimum of a 1-hour rainfall. The development area must have the capacity to detain the 3-hour rainfall.
- On future lot grading plans where subdivision is not required, the 1:50 year outflow rate shall be controlled to a 1:5 year pre-development runoff rate for a 1-hour design storm - before reaching the Municipal ditches. Again, the development area must have the capacity to detain the 3-hour rainfall and the design must comply with the drainage plan design Standards.
- If a lot is being developed and (a) a drainage plan was already completed for the lot and (b) the developer intends to develop the lot to the same runoff value which was anticipated in the previous drainage plan, the lot developer must submit a lot grading plan which is compliant with the Municipality's lot grading design Standard.
- Confirm if the development area is controlled by other regulators along with the Municipality. Map 3, in the appendix, highlights the regulatory areas. If water from the development flows towards the regulatory area or if the lot is flanking the regulatory area, additional design criteria may apply. The developer should discuss potential drainage requirements with that regulatory body.
- Water quality shall be protected through the implementation of sediment and contaminant control techniques.
- Land shall be set aside as public reserve or easement area where required to (a) buffer riparian areas from development areas, and (b) provide flood relief through stormwater detention.

7.2 RESPONSIBILITY OF THE MUNICIPALITY

It is the Municipality's responsibility to ensure that municipal services are implemented, maintained, and enforced as development progresses in an organized fashion and in compliance with the Plan. Moreover, it is equally important that the Municipality maintain and construct infrastructure in a sustainable way.

Municipal responsibilities include:

- Communicate with other areas of government for the establishment and application of uniform Surface Water Management Policies and Standards.
- Plan and maintain drainage infrastructure.
- Identify drainage requirements and convey the municipal needs through the Development Review Committee, as representing the Municipality on the Inland Port Special Planning Authority.
- Perform infrastructure maintenance works including (but not limited to) erosion and sediment control measures.
- Enforce lot grading and drainage works construction and maintenance.
- Revegetate and reforest areas set aside for green space.
- Optimize stormwater detention areas through cleanout, widening of the floodplain bottom, naturalization techniques, and other methods.
- Develop new detention areas where flood relief is required.
- Request and accepting the transfer of second order drains to Public Land when available through the subdivision application process.

7.3 RESPONSIBILITY OF THE PROVINCE

It is the Province's responsibility to interact with the local stakeholders to ensure that local decisions are reflective of Provincial strategies. Moreover, as the Provincial Drain authority, the Province must ensure that drain planning and maintenance programs work in symbiosis with the environment and Plan for the area:

Inland Port Special Planning Authority responsibilities include:

- Ensure the engagement of all stakeholders.
- Facilitate the application process by communicating the steps of the process, stakeholder responsibilities, and timelines.
- Identify and convey requirements for drainage designs on applications through the approval of applications.
- Protect the public and the environment through (a) the preservation of wetland areas and (b) the identification and special treatment of flood prone areas.

Other Provincial responsibilities include:

- Through the Development Review Committee, participate in the review of applications, ensuring applicants are provided with information for drainage compliance.
- Through the Development Review Committee, participate in the establishment of Standards for Rosser CentrePort Lands drainage.
- Through the Departments of (a) Infrastructure, and (b) Water Management and Structures, evaluate and communicate downstream and upstream impacts of new infrastructure projects with other regulatory bodies.
- Communicate and collaborate with the Municipality regarding drain maintenance schedules and planned drainage work.
- Evaluate the condition of Provincial structures and replace or repair them as necessary.
- Participate in planning regarding the transfer of Omand's Creek to regulatory control for the section of the creek that falls within the Rosser CentrePort Lands.
- Clearly communicate applicable Laws, Regulations, Standards, and recommendations regarding drainage and water quality requirements that apply to developers in the Rosser CentrePort Lands.

8 CONCLUSION

This drainage report documents and reviews the existing conditions and drainage impacts that may occur as a result of the development of the Rosser CentrePort Lands. Moreover, the report provides guidelines and recommendations to enhance the regional natural heritage while mitigating potential negative impacts.

In this study, regional stakeholders were consulted and involved in the drainage planning process. The stakeholders were identified as land owners, developers, the Municipality of Rosser, The City of Winnipeg, and the Provincial Government. In many locations within the region, the stormwater runoff directly or indirectly routes into the jurisdiction of other regulatory bodies. The Stormwater Management Policies of the regulatory bodies are discussed and appended to this report where possible. Finally, this report provides clarification to the stakeholder roles, as required for the successful stormwater management during the build-out of the Rosser CentrePort Lands. That is, all parties are required to design, construct, and maintain the land and structures in a sustainable way that mitigates adverse impacts.

The Inland Port Special Planning Authority and Development Review Committee has been established to facilitate and implement the development approval process. By all stakeholders participating in the review process, it is anticipated that drainage requirements will be clearly conveyed and applied, ensuring the protection and preservation of the watershed.

The future vision of the Rosser CentrePort Lands is the development of a highly successful ecological and socio-economical centre for business and tri-modal transport. By integrating drainage designs that protect the environment while facilitating commercial and industrial development, the Rosser CentrePort Lands will become an iconic example of environmental stewardship and sustainability.

9 DEFINITIONS

Catchment Area: Also called catchment basin, local drainage area, or local drainage basin. This is the area of land that collectively drains towards an outlet.

Development Plan: Herein refers to the Inland Port Special Planning Area Regulation, M.R. 48/2016.

Development Area: Lands which are planned and developed in a manner that is consistent with the vision of the Development Plan.

Order Drain: Standard terminology classifying a drain according to the rate of water conveyance. Drain order starts at 1, which is the smallest. Typically, the Province manages any drain with an order of 3 or greater.

Detention: Reducing the rate of surface water flow by use of physical systems such as restrictive pipes, orifices, stony channels, etc.

Detention Pond: The area behind a flow restrictor that temporarily stores excess runoff water. Detention ponds frequently dry out shortly after a storm event.

Inland Port Special Planning Authority: The Planning Authority for the Plan Area, as implemented through Regulation; considers and approves subdivision and zoning applications and performs other duties assigned by the Minister.

Pre-development: Land use prior to the construction of industrial and commercial developments in the Rosser CentrePort Lands area; that is, typically agricultural with graveled mile roads.

Post-development: Full build-out of the Rosser CentrePort Lands in accordance with the Inland Port Special Planning Area Development Plan.

Retention: Installation of a physical barrier that prevents the outflow of stormwater runoff.

Retention Pond: A constructed depression in the land that is designed to hold stormwater and only dries through evaporation. Retention ponds typically have a designed normal water level that is sustained year-round. Sometimes these are referred to as "wet" ponds.

Rural Municipality of Rosser (Rosser): The government body responsible for municipal operations, maintenance of works, and enforcement with respect to services such as municipal drainage, domestic water and sewage service, and provision of emergency services.

Sustainability measure: a stormwater management design feature which provides canopy interception, root uptake, lengthens the time for evaporation, or provides an opportunity for chemical / nutrient deposition.

Sub-basin: Also called sub-catchment. A portion of a watershed identified for study, typically with one defined outlet. A development area may be comprised of several sub-basins, each with defined areas that either converge or do not converge upon leaving a property.

Watershed: The total area that contributes runoff to a basin. The upper extents of a watershed are defined by topographical elevation high points where stormwater would divide into one watershed or another. The lower limit of the watershed is the outlet (typically a lake or river) where the watershed outflow converges with the outflow of other watersheds.

10 REFERENCES

"CentrePort Canada Way Project Omand's Creek at PR 221 Proposed Crossing Hydrologic and Hydraulic Assessment", Bruce Harding, P.Eng, 2011.

"Drainage Criteria Manual for the City of Winnipeg", James F. MacLaren Limited, Willowdale Ontario, 1974.

"Fish Habitat Classification for Manitoba Agricultural Watersheds", Map 062H14, Fisheries and Oceans Canada, 2008.

"Groundwater in Manitoba: Hydrogeology, Quality Concerns, Management", Gary Grove National Hydrology Research Institute and Christian Pupp State of Environment Reporting, National Hydrology Research Institute, 1995.

"Manitoba Stream Crossing Guidelines for the Protection of Fish and Fish Habitat", Fisheries and Oceans, Albert Dreidger (Minister), 1996.

"Netley-Grassmere Integrated Watershed Management Plan", Manitoba Conservation, 2015.

"Open-Channel Hydraulics" Chow, V.T., 1959, New York, McGraw-Hill.

The Prairie Climate Centre – From Risk to Resilience, http://prairieclimatecentre.ca/

"Soils – Winnipeg Region Study Area", Manitoba Soil Survey, Province of Manitoba, 1975

"Soils and Terrain, An Introduction to the Land Resource, Rural Municipality of Rosser, Information Bulletin 99-4", Agriculture and Agri-Food Canada, October 1999.

11 APPENDICIES

Appendix 1: Creeks and Drains

Manitoba-identified creeks and orders within the study area and adjacent areas:

Site Number	Date	Site Name	Latitude (DD)	Longitude (DD)	DES Order	DES Map #	NTS Map #
D-02-001	16-Apr-02	Sturgeon Creek	49.87693	-97.27348	4	26	062H14
D-02-193	20-Aug-02	Second Creek	49.88272	-97.47458	3	26	062H14
D-02-194	20-Aug-02	Truro Creek	49.87796	-97.22497	2	City	062H14
W-03-014	26-May-03	Unnamed tributary to Colony Creek	49.99007	-97.34428	3	26	062H14
W-03-015	26-May-03	Colony Creek	49.99027	-97.37842	3	26	062H14
W-03-016	26-May-03	Unnamed tributary to Sturgeon Creek	49.99027	-97.40468	2	26	062H14
W-03-017	26-May-03	Unnamed tributary to Sturgeon Creek	49.98995	-97.42855	2	26	062H14
W-03-018	26-May-03	Old Sturgeon Creek	49.99022	-97.48455	2	26	062H14
W-03-022	27-May-03	Confluence of Old Sturgeon Creek and Sturgeon Creek	49.97618	-97.48253	2	26	062H14
W-03-023	27-May-03	Unnamed tributary to Sturgeon Creek	49.96797	-97.48207	2	26	062H14
W-03-024	27-May-03	Confluence of Sturgeon Creek and Meridian Drain	49.92637	-97.43190	3	26	062H14
W-03-025	27-May-03	Meridian Drain	49.94593	-97.45923	3	26	062H14
W-03-026	27-May-03	Unnamed tributary to Sturgeon Creek	49.96072	-97.39005	2	26	062H14
B-04-002	1-May-04	East Colony Creek	49.99025	-97.29995	3	26	062H14
		City Protection Drain					

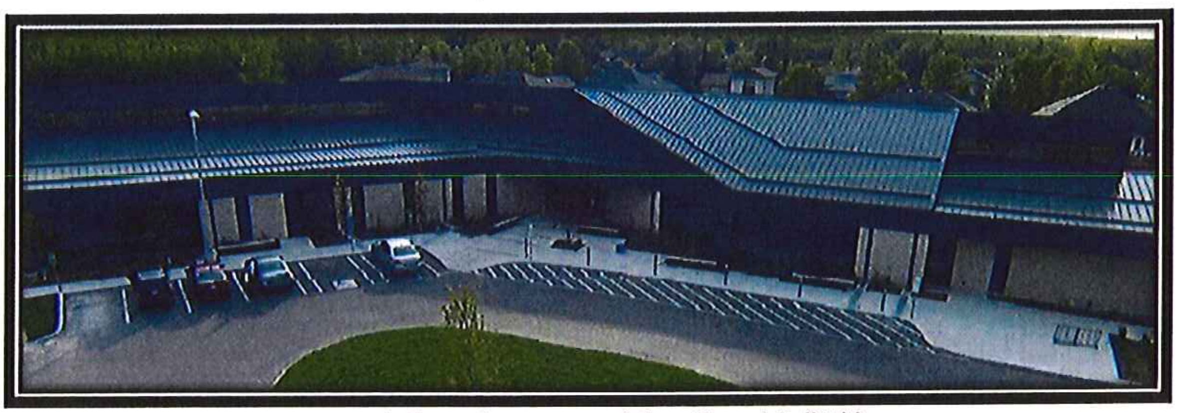
JME World Consultants
www.jme-consultants.com
Box 54 Grp 17 RR2
Dugald MB R0E 0K0

January 22, 2016

Sustainable Landscaping Short Study – Gaynor Family Regional Library, Selkirk

The Gaynor Family Regional Library, in Selkirk, is an excellent example of sustainable landscaping for stormwater management, as it integrates concepts applicable for CentrePort developments. This short report highlights the Library landscaping features and provides recommendations which could be adopted to ensure equally successful results at CentrePort.

The library design was undertaken by a team of professional engineers, architects, and landscape architects. HTFC Planning and Design (Previously known as Hilderman Thomas Frank Cram) led the landscaping design while Prairie Habitats Inc. supplied the vegetative species and completed the landscaping construction works. All elements of the project were considered as a part of a system, and teamwork was paramount. Their creativity resulted an attractive public building nested between an open gathering space, motorized and non-motorized vehicle parking areas, and naturalized landscape.



Aerial Photo (Courtesy of the City of Selkirk)

At the library, the stormwater runoff is attenuated for several benefits:

- Cleansing of runoff from the parking area
- Sediment removal
- Detention and routing to reduce the peak runoff
- Growth of natural and adaptive plant species

Stormwater retention was not required, as a downstream stormwater retention pond accepted the excess water that was generated by the site development, however, detention of stormwater reduced the peak volume of flow, thereby reducing the costs associated with large land drainage pipes.

Essentially, the key runoff control elements include:

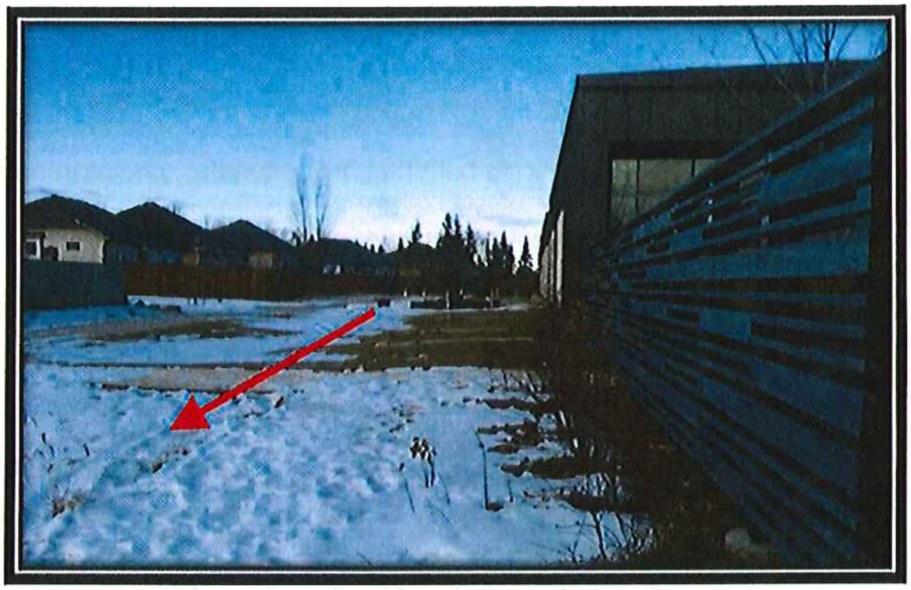
1. Stormwater that is received on the vehicles and parking lot is directed into a rain garden. The rain garden is a pleasant landscaping feature for visitors entering the lot.

Construction of the Rain Garden and Parking Lot (Google Image)

2. At high erosion-risk areas, the ground surfaces are protected from runoff velocity erosion through the use of biological and hard armoring such as splash pads and beds of landscaping wood chips.

Splash pads, grouted riprap, and landscaping wood chips

3. A large swale collects excess stormwater along the west side of the property. The water level in the swale is controlled with an outlet weir, which maintains an appropriate water level for the planted species. Within the swale, several riffles and pools are also installed to provide sediment traps and evaporation / infiltration opportunities.



Side yard swale with velocity reducing elements

4. As the runoff water travels southward past the library, the plant species vary from upland to marsh species, to match the designed wetness of that area.

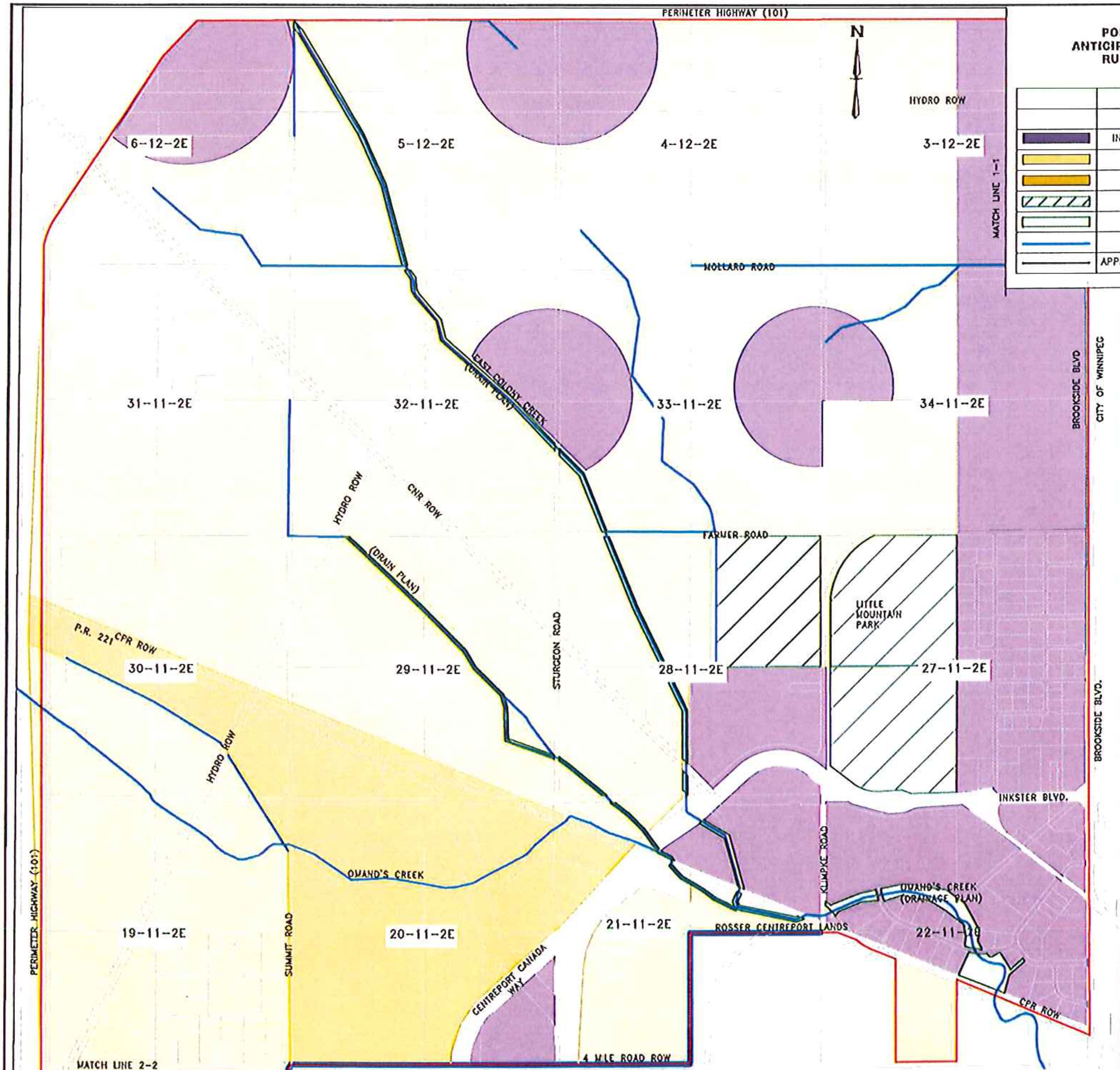
Naturalized Area with Marsh Grasses

5. A low control structure at the south side of the property acts to control the water in the wetland area.

Several important planning characteristics ensured the success of the library sustainable landscaping. Site development preparation for design and construction should include:

- Require that bidding architect and engineering teams include a landscape architect trained in sustainable landscape design
- Institute design requirements for wind buffering, microclimates, and stormwater attenuation
- Focus landscaping design on no-maintenance or low-maintenance adaptive plant species and softscaping
- Ensure that lot development plans use interconnected systems through the application of area concept plans

Sustainable landscaping planning and construction offers many environmental and socio-economic benefits for the CentrePort region. The Gaynor Family Regional Library, in Selkirk, is an example of how stormwater detention and naturalized vegetation can beautify and protect the environment while assuring the functionality of the site.



POST-DEVELOPMENT ANTICIPATED UNCONTROLLED RUNOFF C-VALUE BY LAND USE

	LEGEND-PLAN	
	LAND USE	UNCONTROLLED RUNOFF COEFF.
	INDUSTRIAL GENERAL	C = 0.8
	MANUFACTURING	C = 0.7
	RAIL SERVICE	C = 0.8
	GREEN SPACE	C = 0.3
	DRAINAGE PLAN	C = 1.0
	DRAINAGE PATH	C = 1.0
	APPROX. PROPERTY LIMIT	

RURAL MUNICIPALITY ROSSER

ROSSER CENTREPORT LANDS

DEVELOPMENT TYPE OF USE

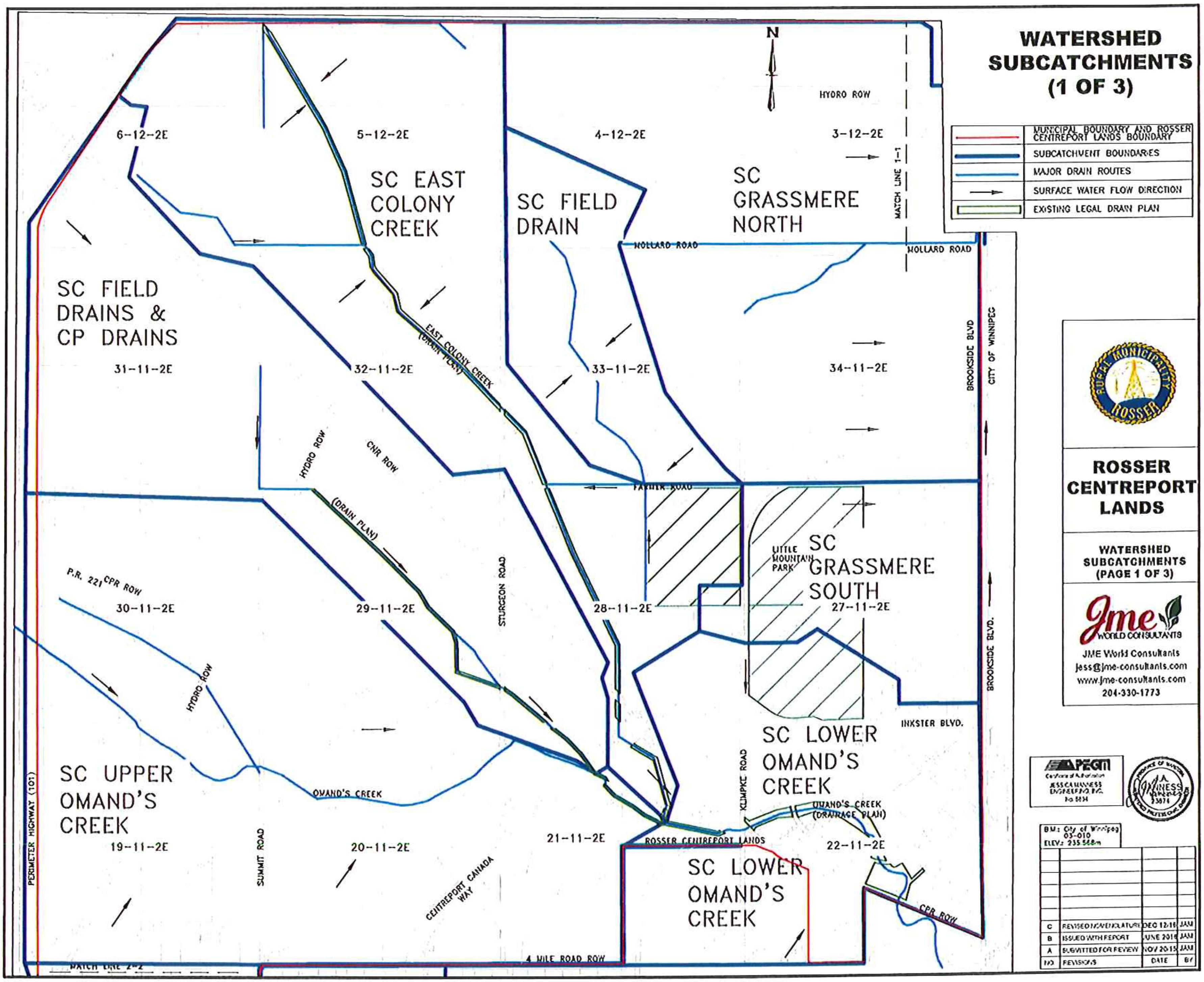
JME WORLD CONSULTANTS
JME World Consultants
jess@jme-consultants.com
www.jme-consultants.com
204-330-1773

APEGM Certificate of Authorization JESSICA MANNESS ENGINEERING INC. No. 5834

J.A. MANNESS Member 23374

BM: City of Winnipeg 03-010
ELEV.: 235.568m

NO.	REVISIONS	DATE	BY
C	REVISED NOMENCLATURE	DEC 12 16	JAM
B	ISSUED WITH REPORT	JUNE 2016	JAM
A	SUBMITTED FOR REVIEW	NOV 2015	JAM


WATERSHED SUBCATCHMENTS (1 OF 3)
MUNICIPAL BOUNDARY AND ROSSER CENTREPORT LANDS BOUNDARY
SUBCATCHMENT BOUNDARIES
MAJOR DRAIN ROUTES
SURFACE WATER FLOW DIRECTION
EXISTING LEGAL DRAIN PLAN
N
HYDRO ROW
6-12-2E
5-12-2E
4-12-2E
3-12-2E
SC EAST COLONY CREEK
SC FIELD DRAIN
SC GRASSMERE NORTH
MATCH LINE 1-1
HOLLARD ROAD
SC FIELD DRAINS & CP DRAINS
EAST COLONY CREEK (DRAIN PLAN)
31-11-2E
32-11-2E
33-11-2E
34-11-2E
BROOKSIDE BLVD
CITY OF WINNIPEG
HYDRO ROW
CNR ROW
FARMER ROAD
(DRAIN PLAN)
LITTLE MOUNTAIN PARK
SC GRASSMERE SOUTH
P.R. 221 CPR ROW
30-11-2E
29-11-2E
STURGEON ROAD
28-11-2E
27-11-2E
HYDRO ROW
INKSTER BLVD.
BROOKSIDE BLVD.
SC UPPER OMAND'S CREEK
OMAND'S CREEK
SC LOWER OMAND'S CREEK
KLIMPKE ROAD
OMAND'S CREEK (DRAINAGE PLAN)
19-11-2E
20-11-2E
21-11-2E
22-11-2E
ROSSER CENTREPORT LANDS
SC LOWER OMAND'S CREEK
PERIMETER HIGHWAY (101)
SUMMIT ROAD
CENTREPORT CANADA WAY
CPR ROW
MATCH LINE 2-2
4 MILE ROAD ROW
ROSSER CENTREPORT LANDS
WATERSHED SUBCATCHMENTS (PAGE 1 OF 3)
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jess@jme-consultants.com
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APEGM
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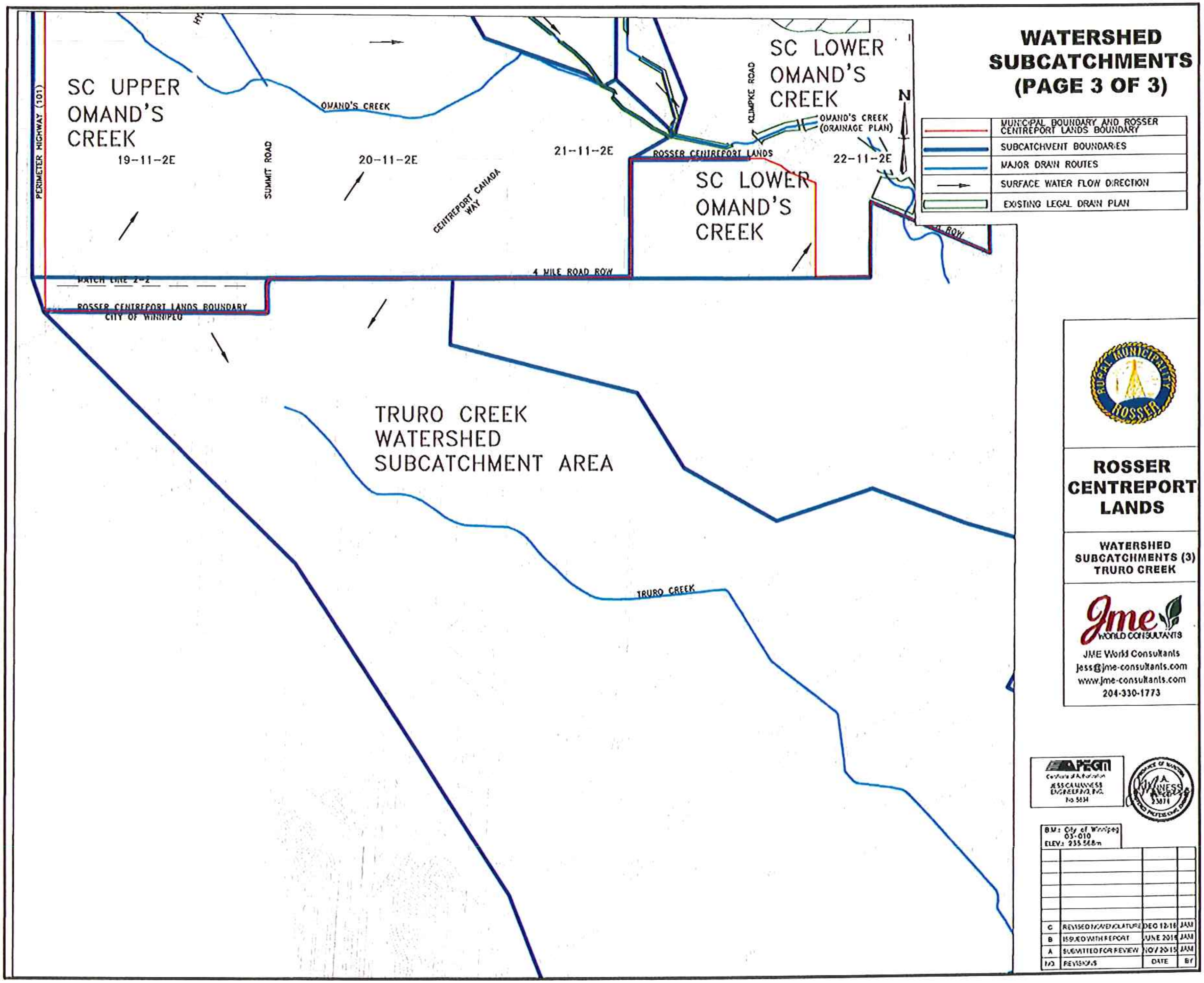
WATERSHED SUBCATCHMENTS (PAGE 3 OF 3)
SC UPPER OMAND'S CREEK
SC LOWER OMAND'S CREEK
SC LOWER OMAND'S CREEK
TRURO CREEK WATERSHED SUBCATCHMENT AREA
19-11-2E
20-11-2E
21-11-2E
22-11-2E
PERIMETER HIGHWAY (101)
SUMMIT ROAD
CENTREPORT CANADA WAY
KLIMPKE ROAD
OMAND'S CREEK
OMAND'S CREEK (DRAINAGE PLAN)
ROSSER CENTREPORT LANDS
4 MILE ROAD ROW
MATCH LINE 2-2
ROSSER CENTREPORT LANDS BOUNDARY
CITY OF WINNIPEG
TRURO CREEK
N
MUNICIPAL BOUNDARY AND ROSSER CENTREPORT LANDS BOUNDARY
SUBCATCHMENT BOUNDARIES
MAJOR DRAIN ROUTES
SURFACE WATER FLOW DIRECTION
EXISTING LEGAL DRAIN PLAN
ROSSER CENTREPORT LANDS
WATERSHED SUBCATCHMENTS (3) TRURO CREEK
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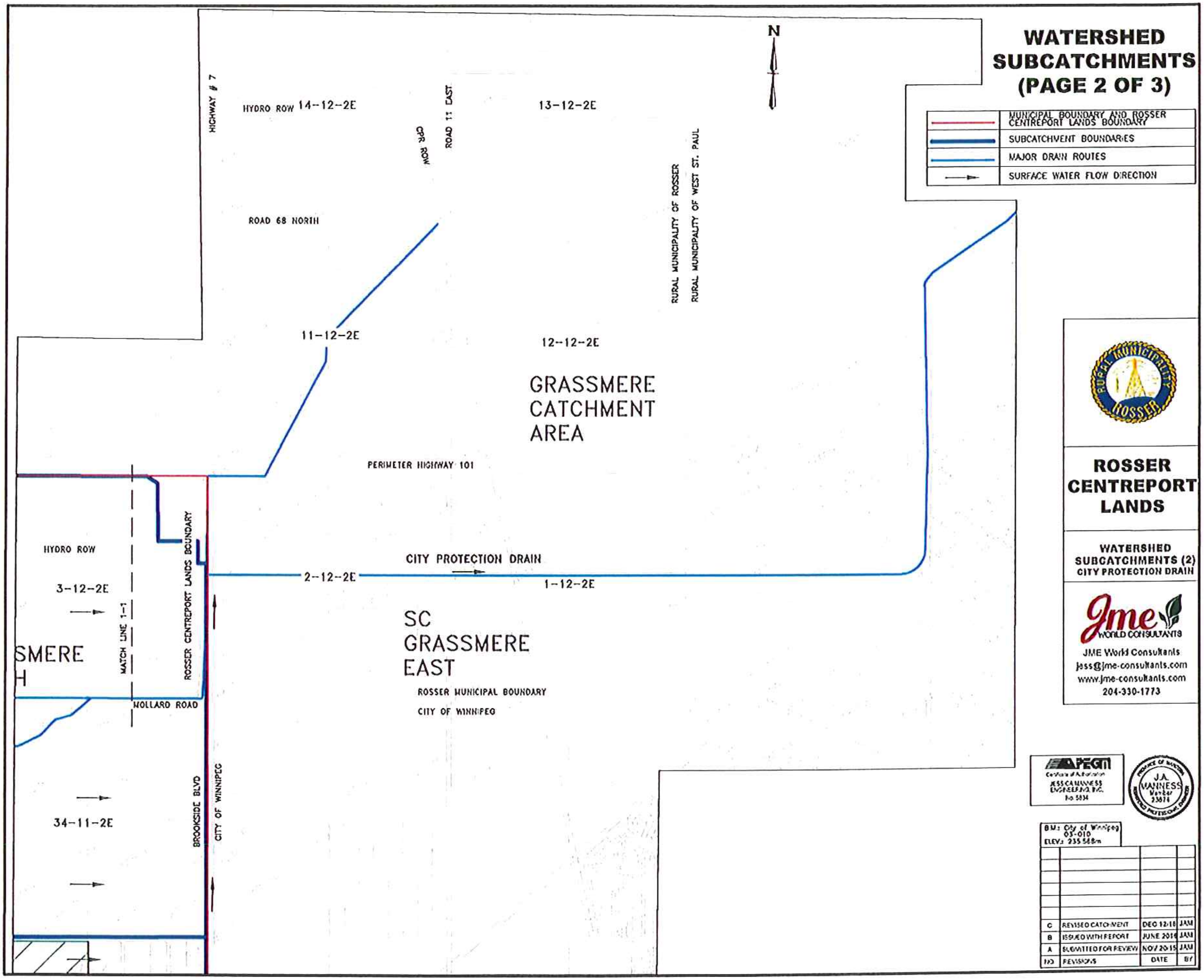

WATERSHED SUBCATCHMENTS (PAGE 2 OF 3)
MUNICIPAL BOUNDARY AND ROSSER CENTREPORT LANDS BOUNDARY
SUBCATCHMENT BOUNDARIES
MAJOR DRAIN ROUTES
SURFACE WATER FLOW DIRECTION
N
HIGHWAY # 7
HYDRO ROW
14-12-2E
CPR ROW
ROAD 11 EAST
13-12-2E
RURAL MUNICIPALITY OF ROSSER
RURAL MUNICIPALITY OF WEST ST. PAUL
ROAD 68 NORTH
11-12-2E
12-12-2E
GRASSMERE CATCHMENT AREA
PERIMETER HIGHWAY 101
HYDRO ROW
CITY PROTECTION DRAIN
2-12-2E
1-12-2E
3-12-2E
MATCH LINE 1-1
ROSSER CENTREPORT LANDS BOUNDARY
SMERE
H
SC GRASSMERE EAST
ROSSER MUNICIPAL BOUNDARY
CITY OF WINNIPEG
MOLLARD ROAD
34-11-2E
BROOKSIDE BLVD
CITY OF WINNIPEG
ROSSER CENTREPORT LANDS
WATERSHED SUBCATCHMENTS (2) CITY PROTECTION DRAIN
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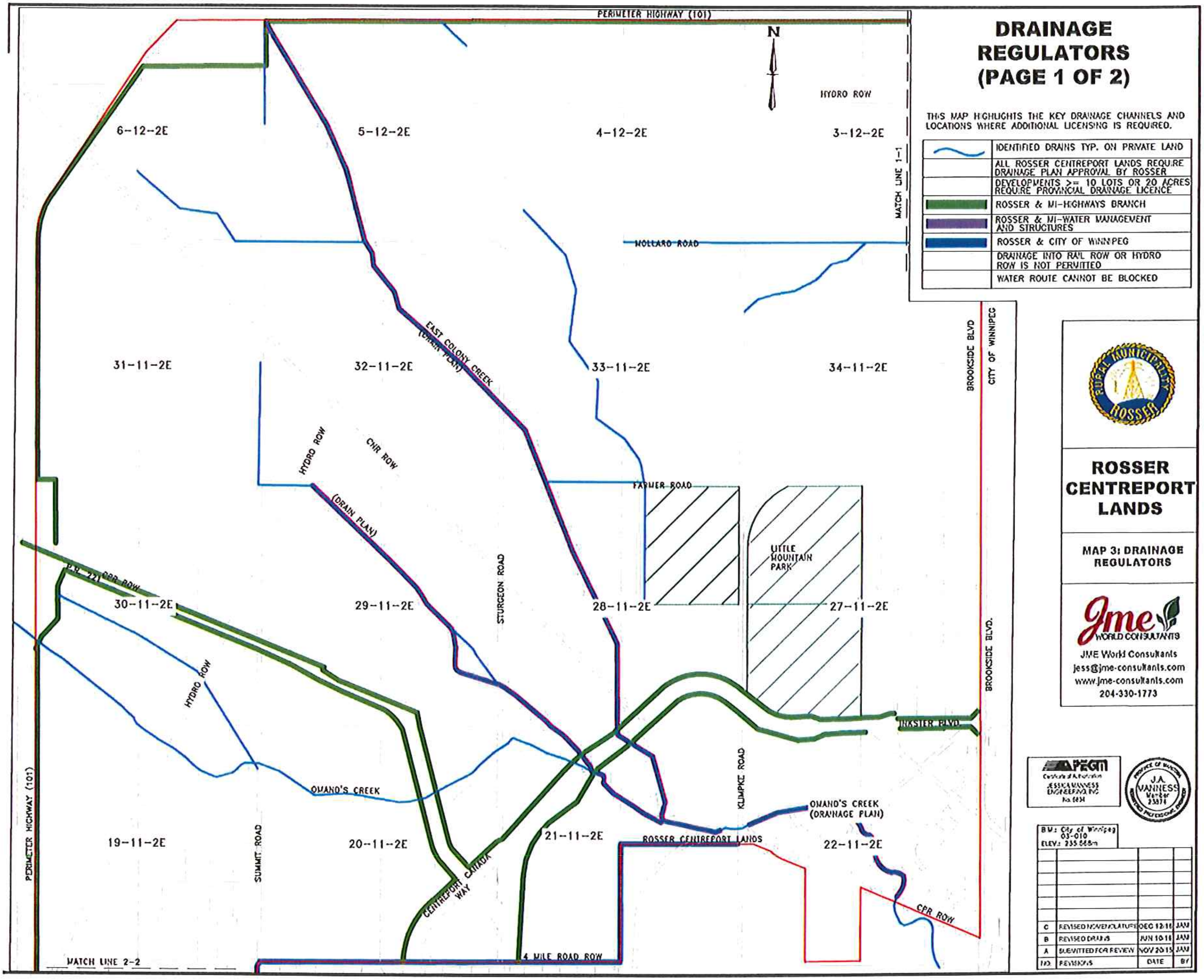
DRAINAGE REGULATORS (PAGE 1 OF 2)
THIS MAP HIGHLIGHTS THE KEY DRAINAGE CHANNELS AND LOCATIONS WHERE ADDITIONAL LICENSING IS REQUIRED.
IDENTIFIED DRAINS TYP. ON PRIVATE LAND
ALL ROSSER CENTREPORT LANDS REQUIRE DRAINAGE PLAN APPROVAL BY ROSSER
DEVELOPMENTS >= 10 LOTS OR 20 ACRES REQUIRE PROVINCIAL DRAINAGE LICENCE
ROSSER & MI-HIGHWAYS BRANCH
ROSSER & MI-WATER MANAGEMENT AND STRUCTURES
ROSSER & CITY OF WINNIPEG
DRAINAGE INTO RAIL ROW OR HYDRO ROW IS NOT PERMITTED
WATER ROUTE CANNOT BE BLOCKED
ROSSER CENTREPORT LANDS
MAP 3: DRAINAGE REGULATORS
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PERIMETER HIGHWAY (101)
N
HYDRO ROW
6-12-2E
5-12-2E
4-12-2E
3-12-2E
MATCH LINE 1-1
MOLLARD ROAD
31-11-2E
32-11-2E
33-11-2E
34-11-2E
EAST COLONY CREEK (DRAIN PLAN)
BROOKSIDE BLVD
CITY OF WINNIPEG
HYDRO ROW
CNR ROW
FARMER ROAD
(DRAIN PLAN)
LITTLE MOUNTAIN PARK
STURGEON ROAD
P.R. 221
CPR ROW
30-11-2E
29-11-2E
28-11-2E
27-11-2E
BROOKSIDE BLVD.
HYDRO ROW
INKSTER BLVD
KLIMPKE ROAD
OMAND'S CREEK
OMAND'S CREEK (DRAINAGE PLAN)
PERIMETER HIGHWAY (101)
SUMMIT ROAD
19-11-2E
20-11-2E
21-11-2E
ROSSER CENTREPORT LANDS
22-11-2E
CENTREPORT CANADA WAY
CPR ROW
MATCH LINE 2-2
4 MILE ROAD ROW
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B REVISED DRAINS JUN 10-16 JAM
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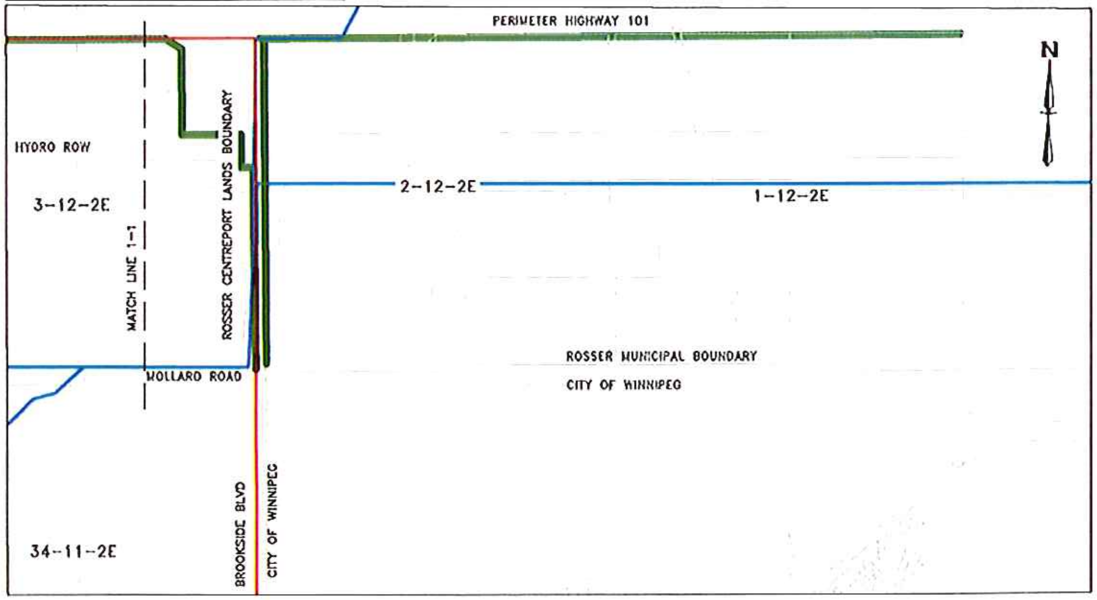
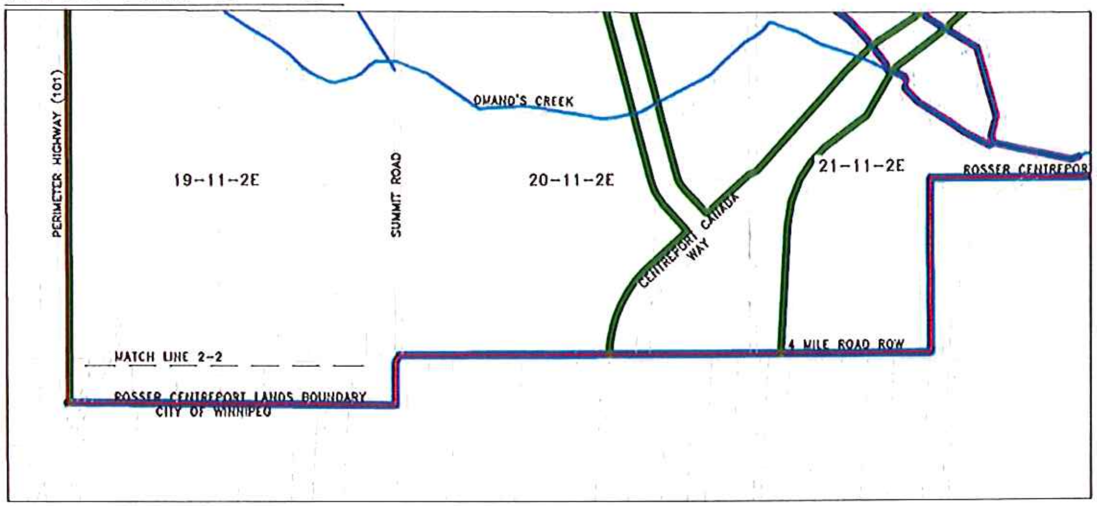
DRAINAGE REGULATORS (PAGE 2 OF 2)

MATCH LINE 1 – 1



MATCH LINE 2 – 2



THIS MAP HIGHLIGHTS THE KEY DRAINAGE CHANNELS AND LOCATIONS WHERE ADDITIONAL LICENSING IS REQUIRED.

(blue wavy line)	IDENTIFIED DRAINS TYP. ON PRIVATE LAND
	ALL ROSSER CENTREPORT LANDS REQUIRE DRAINAGE PLAN APPROVAL BY ROSSER
	DEVELOPMENTS >= 10 LOTS OR 20 ACRES REQUIRE PROVINCIAL DRAINAGE LICENCE
(green)	ROSSER & MI-HIGHWAYS BRANCH
(purple)	ROSSER & MI-WATER MANAGEMENT AND STRUCTURES
(blue)	ROSSER & CITY OF WINNIPEG
	DRAINAGE INTO RAIL ROW OR HYDRO ROW IS NOT PERMITTED
	WATER ROUTE CANNOT BE BLOCKED

RURAL MUNICIPALITY ROSSER

ROSSER CENTREPORT LANDS

MAP 3: DRAINAGE REGULATORS

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JME World Consultants
jess@jme-consultants.com
www.jme-consultants.com
204-330-1773

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No. 6834

PROVINCE OF MANITOBA
J.A. VANNESS
Member 23874
REGISTERED PROFESSIONAL ENGINEER

B.M.: City of Winnipeg 03-010
ELEV.: 235.568m

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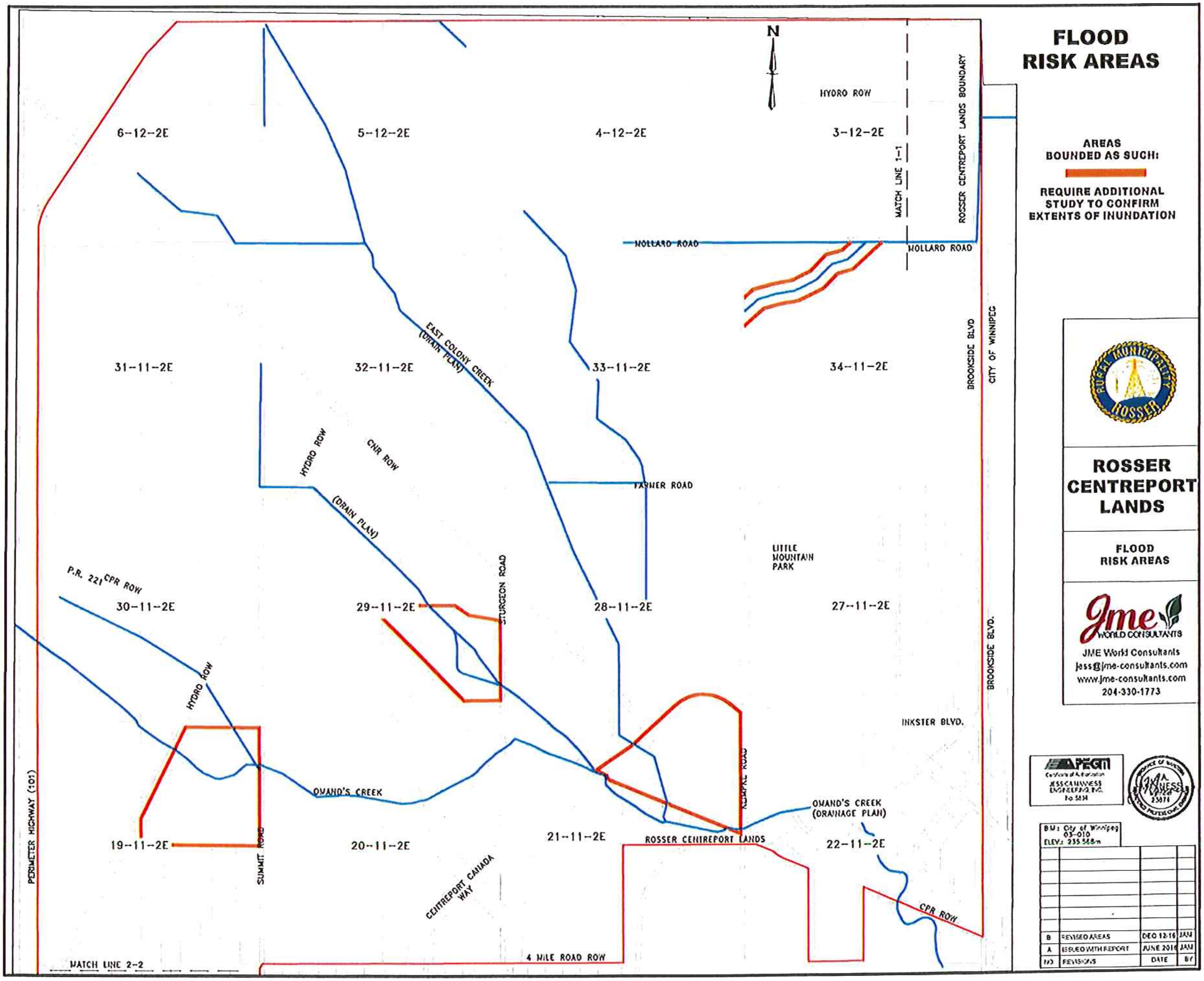
FLOOD RISK AREAS
AREAS BOUNDED AS SUCH:
REQUIRE ADDITIONAL STUDY TO CONFIRM EXTENTS OF INUNDATION
ROSSER CENTREPORT LANDS
FLOOD RISK AREAS
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N
HYDRO ROW
ROSSER CENTREPORT LANDS BOUNDARY
MATCH LINE 1-1
6-12-2E
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28-11-2E
27-11-2E
BROOKSIDE BLVD.
HYDRO ROW
INKSTER BLVD.
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KEMPAL ROAD
OMAND'S CREEK (DRAINAGE PLAN)
PERIMETER HIGHWAY (101)
19-11-2E
SUMMIT ROAD
20-11-2E
21-11-2E
ROSSER CENTREPORT LANDS
22-11-2E
CENTREPORT CANADA WAY
CPR ROW
MATCH LINE 2-2
4 MILE ROAD ROW
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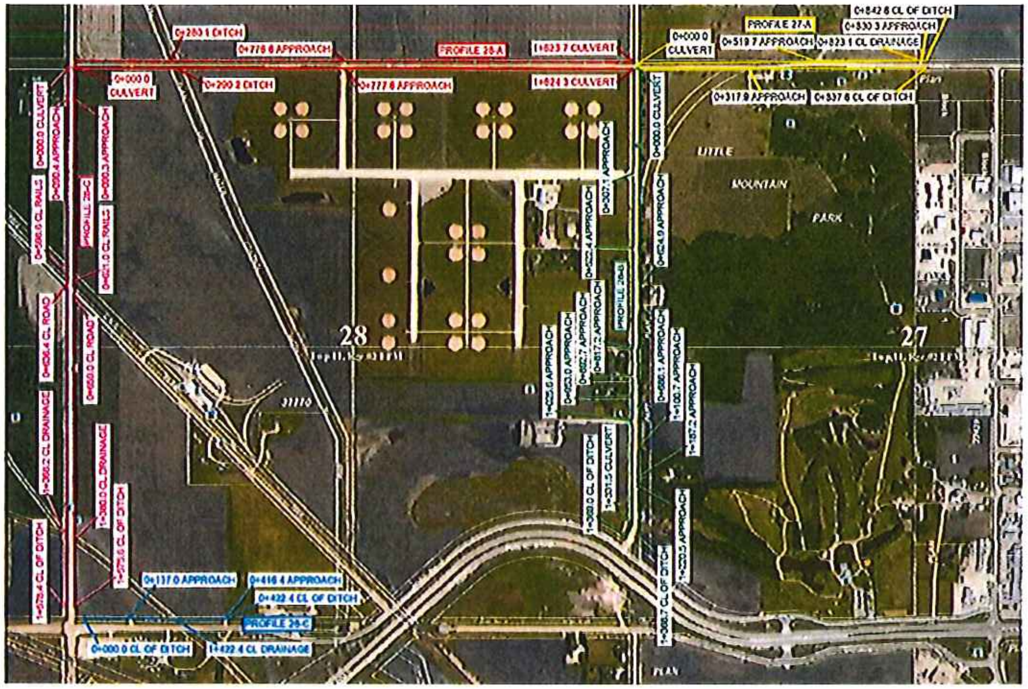
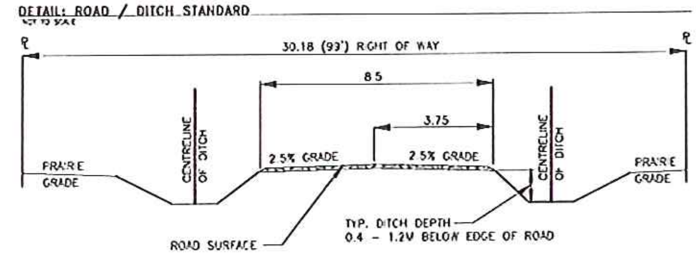
Rosser CentrePort Lands Culvert Inventory - Assessed October 2015

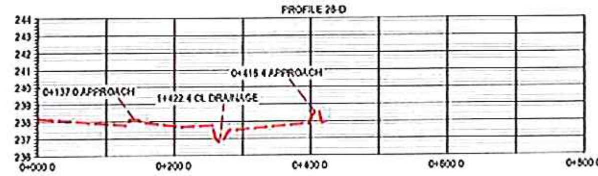
Road Name	North Inv	South Inv	East Inv	West Inv	Material	Diam (mm)	Length (m)	Condition	Efficiency	Effective Diam (mm)	Slope	n	Capacity (L/s)	Potential Capacity
Klimpke Rd	237.3	237.254			CMP	600	13	GC	100%	600	0.003538	0.024	197.8	197.8
Klimpke Rd			237.244	236.737	CMP	825	10	GC, plugged	80%	660	0.0507	0.024	965.6	1760.7
Klimpke Rd	238.524	238.538			CMP	375	11	GC, plugged	80%	300	0.001273	0.024	18.7	33.9
Klimpke Rd	240.009	239.91			CMP	375	8	GC	100%	375	0.012375	0.024	105.6	105.6
Klimpke Rd	238.659	238.651			CMP	500	10.5	GC, plugged	80%	400	0.000762	0.024	31.1	56.5
Klimpke Rd	239.188	239.148			CMP	500	15.5	GC	100%	500	0.002581	0.024	103.9	103.9
Klimpke Rd	240.026	240.112			CMP	450	7	GC	100%	450	0.012286	0.024	171.2	171.2
Klimpke Rd	239.76	239.64			CMP	750	10.5	Major damage, plugged	40%	300	0.011429	0.024	56.0	644.7
Klimpke Rd	240.16	240.138			CMP	500	8.5	Major damage, plugged	40%	200	0.001412	0.024	6.7	76.8
Klimpke Rd	240.655	240.616			CMP	500	6.5	GC	100%	500	0.006	0.024	158.4	158.4
Klimpke Rd	240.473	240.328			CMP	450	16	GC, some soil	95%	427.5	0.009063	0.024	128.2	147.0
Klimpke Rd	241.113	241.016			CMP	450	7	GC, some soil	95%	427.5	0.013857	0.024	158.6	181.8
Klimpke Rd	241.18	240.897				500	18		100%	500	0.015722	0.024	256.5	256.5
Klimpke Rd	240.712	240.615			CMP	750	42.5	Minor damage	95%	712.5	0.004635	0.024	358.1	410.6
Klimpke Rd	239.791	239.575			Concrete	600	14	GC	100%	600	0.015429	0.012	826.2	826.2
Klimpke Rd	239.173	239.034			CMP	450	11.5	GC, plugged	50%	225	0.012087	0.024	26.7	169.8
Klimpke Rd	238.87	238.84			CMP	450	11.5	GC, plugged	50%	225	0.002609	0.024	12.4	78.9
Klimpke Rd	238.89	238.864			CMP	450	12	GC	100%	450	0.002167	0.024	71.9	71.9
Klimpke Rd	238.445	238.401			CMP	450	12.5	GC, some soil	50%	225	0.00352	0.024	14.4	91.6
Klimpke Rd	238.533	238.527			CMP	450	10	GC	100%	450	0.0006	0.024	37.8	37.8
Klimpke Rd	238.355	238.259			CMP	600	18.5	Major damage	50%	300	0.005189	0.024	37.7	239.6
Klimpke Rd	238.354	238.339			CMP	450	10	Minor damage, some soil	80%	360	0.0015	0.024	33.0	69.8
Klimpke Rd	238.133	238.035			Concrete	450	10.5	GC, some soil	95%	427.5	0.009333	0.012	260.2	298.4
Klimpke Rd	238.193	238.274			CMP	500	6	GC, some soil	95%	475	0.0135	0.024	207.3	237.6
Klimpke Rd			238.012	237.8994	CMP	600	23	GC, some soil	95%	570	0.004896	0.024	203.0	232.7
Sturgeon Rd		239.303			CMP	450	NA	Minor damage, plugged	50%	225	?	0.024	?	?
Sturgeon Rd	240.008	240.157			CMP	375	6.5	Major damage, plugged	50%	187.5	0.022923	0.024	22.6	143.8
Sturgeon Rd	239.886	239.811			CMP	450	7	Major damage, plugged	50%	225	0.010714	0.024	25.2	159.9
Sturgeon Rd	240.712	240.632			CMP	600	11.5	Minor damage, some soil	80%	480	0.006957	0.024	163.0	277.4
Sturgeon Rd	238.466	238.316			CMP	500	9.5	GC, some soil	95%	475	0.015789	0.024	224.1	257.0
Sturgeon Rd	237.911	237.957			CMP	450	9	GC, some soil	95%	427.5	0.005111	0.024	96.3	110.4
Sturgeon Rd	236.726	236.679			CMP	1350	27.6	GC	100%	1350	0.001709	0.024	1195.2	1195.2
Sturgeon Rd	236.783	236.619			CMP	1350	27.6	GC	100%	1350	0.005964	0.024	2232.8	2232.8
Sturgeon Rd	238.041	238.114			CMP	450	9	GC, some soil	95%	427.5	0.008111	0.024	121.3	139.1
Sturgeon Rd	239.222	239.234				450	9		100%	450	0.001333	0.024	56.4	56.4
Sturgeon Rd	239.13	239.247				450	14		100%	450	0.008357	0.024	141.2	141.2
Sturgeon Rd	239.074	239.055			ABS	450	9	GC, some soil	95%	427.5	0.002111	0.024	61.9	71.0

Sturgeon Rd	238.747				CMP	450		Minor damage, plugged, missing other end	10%	45	?	0.024	?	?
Sturgeon Rd	238.591	238.549			CMP	600	15	GC, plugged	40%	240	0.0028	0.024	15.3	176.0
Sturgeon Rd	237.705	237.698			CMP	750	15.5	GC, some soil	95%	712.5	0.000452	0.024	111.8	128.1
Sturgeon Rd			236.707	236.603	CMP	1200	22	Major damage, reeds	30%	360	0.004727	0.024	58.6	1452.0
Sturgeon Rd	236.208	236.099				1650	26.5		100%	1650	0.004113	0.024	3166.3	3166.3
Sturgeon Rd	236.221	236.047				1650	26.5		100%	1650	0.006566	0.024	4000.5	4000.5
Summit Rd	239.47	239.555				375	14.5		100%	375	0.005862	0.024	72.7	72.7
Summit Rd	238.689	238.744				900	11		100%	900	0.005	0.024	693.4	693.4
Summit Rd	238.261	238.332				600	15		100%	600	0.004733	0.024	228.8	228.8
Summit Rd			238.387	238.443	CMP	450	10	Major damage, plugged	30%	135	0.0056	0.024	4.7	116.6
Summit Rd	238.502	238.454				450	6.5		100%	450	0.007385	0.024	132.7	132.7
Summit Rd	238.563	238.593			CMP	600	7.5	Minor damage, plugged	95%	570	0.004	0.024	183.5	210.3
Summit Rd	237.734	237.756			CMP	500	13	Major damage, some soil	95%	475	0.001692	0.024	73.4	84.1
Summit Rd	237.733	237.829				500	10.5		100%	500	0.009143	0.024	195.6	195.6
Mollard Road			233.635	233.764	CMP	1050	17	GC	100%	1050	0.007588	0.024	1288.5	1288.5
Mollard Road			235.826	235.851	CMP	675	15	minor damage, plugged up	60%	405	0.001667	0.024	47.6	185.9
Mollard Road				240.664	CMP	750		major damage, plugged up, East end plugged shut	20%	150	?	0.024	?	?
Mollard Road			240.52	240.451	CMP	450	9	GC	100%	450	0.007667	0.024	135.2	135.2
Mollard Road				240.192	CMP	450		major damage, plugged up, East end plugged shut	10%	45	?	0.024	?	?
Mollard Road			240.057	240.082	CMP	450	9.5	minor damage	90%	405	0.002632	0.024	69.8	79.2
Mollard Road			239.615	239.636	CMP	600	8	GC, plugged up	50%	300	0.002625	0.024	26.8	170.4
Mollard Road			239.096	239.09	CMP	900	9.5	GC, soil and garbage	80%	720	0.000632	0.024	135.9	240.4
Mollard Road			239.108	239.035	CMP	500	10	minor damage, soil	95%	475	0.0073	0.024	152.4	174.7
Mollard Road	237.162	237.143			CMP	1350	22	GC	100%	1350	0.000864	0.024	849.6	849.6
Mollard Road	237.032	237.186			CMP	1350	22	GC	100%	1350	0.007	0.024	2418.9	2418.9
Mollard Road			238.687	238.769	CMP	375	9.5	major damage, plugged up	50%	187.5	0.008632	0.024	13.9	88.2
Mollard Road			238.299	238.359	CMP	750	10	minor damage, soil	95%	712.5	0.006	0.024	407.4	467.1
Mountainview Rd			235.339	235.393	CMP	600	25	minor damage	95%	570	0.00216	0.024	134.8	164.6
	235.381	235.461			CMP	450		GC	100%	450	?	0.024	?	?
			243.094	242.998	CMP	300	10	GC, soil	95%	285	0.0096	0.024	44.8	51.3
			237.879	238.065	CMP	500	10	GC, soil	95%	475	0.0186	0.024	243.3	278.9
			237.516	237.661	CMP	500	10	GC, soil	95%	475	0.0145	0.024	214.8	246.3
Wheatfield Rd			235.944	235.971	CMP	600	22	GC	100%	600	0.001227	0.024	116.5	116.5
	241.18	240.897			CMP	500	18	major damage, soil	50%	250	0.015722	0.024	40.4	256.5
			238.413	238.51	CMP	675	24.5	GC, plugged up	50%	337.5	0.003959	0.024	45.1	286.5
			238.63	238.464	CMP	750	15	GC	100%	750	0.011067	0.024	634.4	634.4
	236.661	236.66			CMP	1500	24.5	GC	100%	1500	4.08E-05	0.024	244.6	244.6
	236.502	236.52			CMP	1500	24.5	GC	100%	1500	0.000735	0.024	1037.8	1037.8
			238.289	238.17	CMP	450	9	squished (oval), soil	90%	405	0.013222	0.024	134.1	177.6

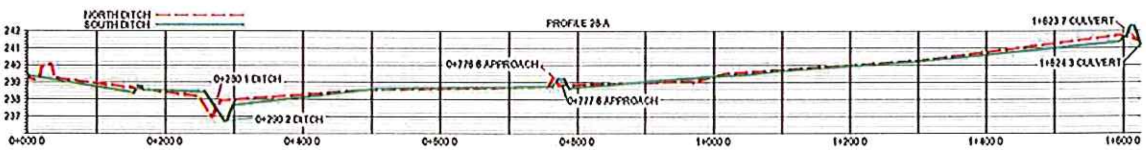
	239.222	239.234			CMP	450	9	major damage, plugged up	50%	225	0.001333	0.024	8.9	56.4
Inkster Blvd			237.481		CMP	600		GC, soil	100%	600	?	0.024	?	?
Inkster Blvd			237.851	237.75	CMP	450	12.5	minor damage, soil	100%	450	0.00808	0.024	138.8	138.8
Inkster Blvd					CMP	1050	36	old, very rusty, no bottom	90%	945	?	0.024	?	?
Prairie Dog Trail	236.221	236.208			CMP	1650	26.5	GC	100%	1650	0.000491	0.024	1093.6	1093.6
Prairie Dog Trail		236.047	236.099		CMP	1650	26.5	GC	100%	1650	8.909396	0.024	147361.9	147361.9
Prairie Dog Trail	238.857	238.97			CMP	375	12.5	minor damage	95%	356.25	0.00904	0.024	78.8	90.3
Prairie Dog Trail	238.646	238.713			CMP	375	13	minor damage, soil	95%	356.25	0.005154	0.024	69.6	68.2

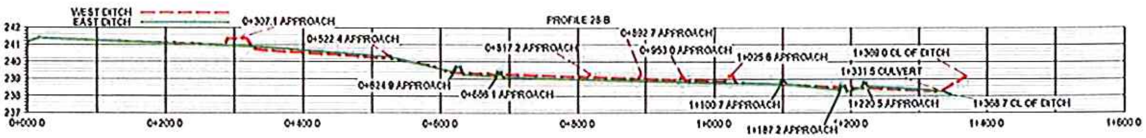


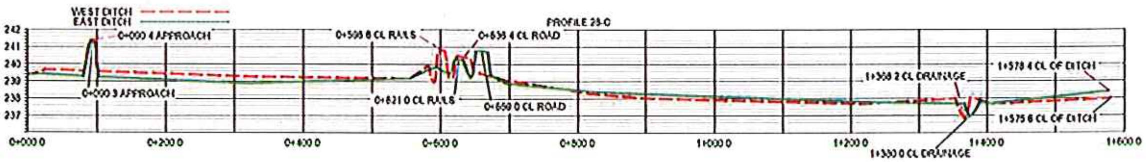




*NOTE: ALL DATA IS DISPLAYED AS SURVEYED BY LANGHOUT LAND SURVEYING & GEOMATICS







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ROSSER CENTREPORT

MUNICIPAL DITCH PROFILES

RM OF ROSSER
CENTREPORT CANADA
RM OF ROSSER

SHEET 1 OF 4

JME World Consultants
jess@jme-consultants.com
www.jme-consultants.com
204-330-1773

DESIGNED: TYS
DRAWN: TYS
SCALE: 1:15,000
DATE DRAWN: NOV 20, 2015
PROJECT NUMBER: 1404039
DATE OF SURVEY: VARIES

NO	REVISIONS	DATE	BY	CHK
A	SUBMITTED FOR REVIEW			

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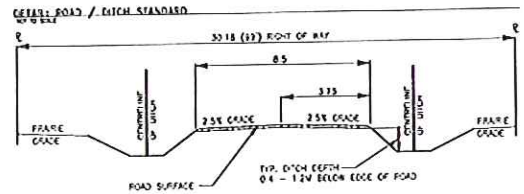
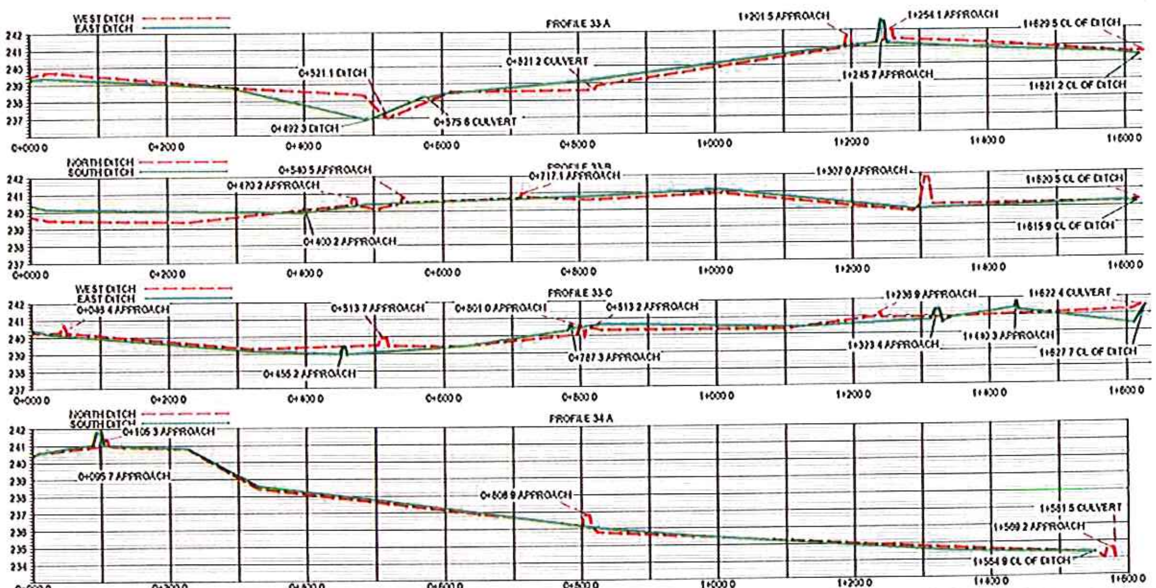
Certificate of Authorization
JESSICA MANNESS ENGINEERING INC.
No. 5834

J.A. MANNESS
Member 23374

JME-001-1





*NOTE: ALL DATA IS DISPLAYED AS SURVEYED BY LANGHOUT LAND SURVEYING & GEOMATICS

JME WORLD CONSULTANTS

TYSMOR DRAFTING SERVICES LTD
WWW.TYSMOR.COM

ROSSER CENTREPORT

MUNICIPAL DITCH PROFILES

RM OF ROSSER
CENTREPORT CANADA
RM OF ROSSER

SHEET 2 OF 4

JME World Consultants
jess@jme-consultants.com
www.jme-consultants.com
204 330-1773

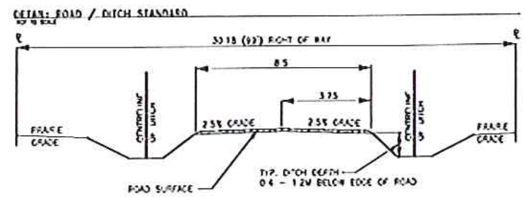
DESIGNED: TYS
DRAWN: TYS
SCALE: 1:15,000
PROJECT NUMBER: 1404039
DATE DRAWN: NOV 20, 2015
DATE OF SURVEY: VARIES

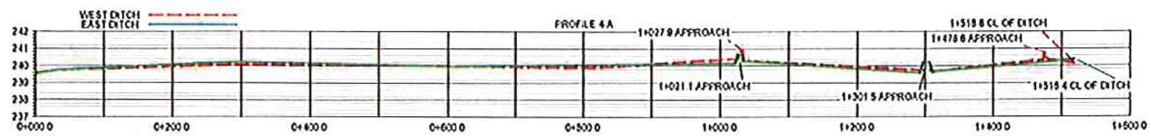
NO	REVISIONS	DATE	BY	CKD
A	SUBMITTED FOR REVIEW			

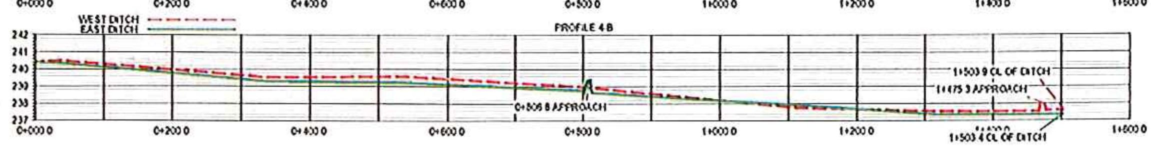
APEGM
Certificate of Authorization
JESSICA MANNESS
ENGINEERING INC.
No. 5934

J.A. MANNESS
Member
23874

JME-001-2







*NOTE: ALL DATA IS DISPLAYED AS SURVEYED BY LANGHOUT LAND SURVEYING & GEOMATICS

JME WORLD CONSULTANTS

TVSMDR DRAFTING SERVICES LTD

ROSSER CENTREPORT

MUNICIPAL DITCH PROFILES

RM OF ROSSER
CENTREPORT CANADA
RM OF ROSSER

SHEET 3 OF 4

JME World Consultants
jess@jme-consultants.com
www.jme-consultants.com
204-330-1773

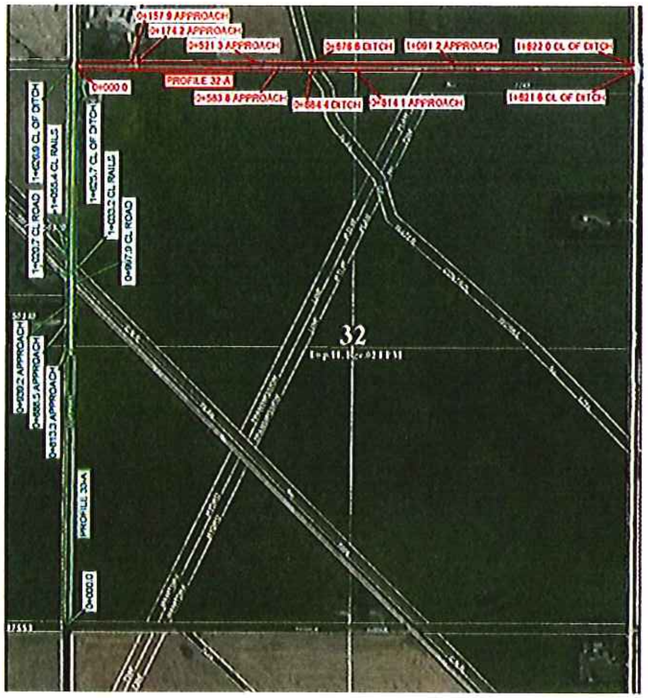
DESIGNED: TVS
DRAWN: TVS
SCALE: 1:15,000
PROJECT NUMBER: 1404039
DATE DRAWN: NOV 20, 2015
DATE OF SURVEY: VARIES

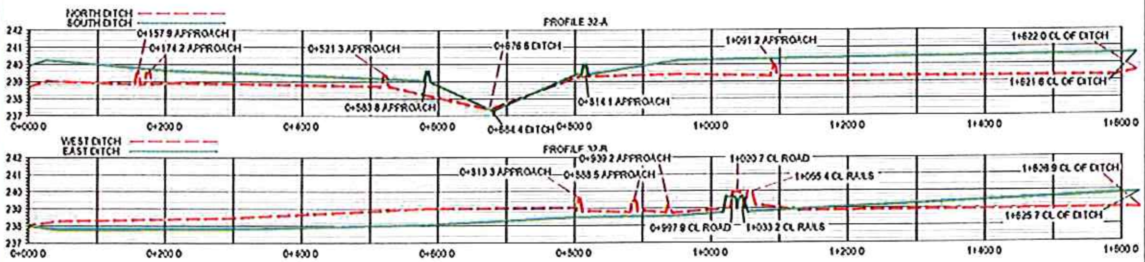
A — SUBMITTED FOR REVIEW

APEGM Certificate of Authorization
JESSICA VANNESS ENGINEERING INC.

J.A. VANNESS Member 23874

JME-001-3

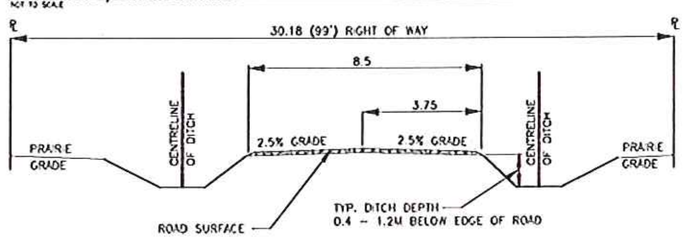




N

*NOTE: ALL DATA IS DISPLAYED AS SURVEYED BY LANKHOUT LAND SURVEYING & GEOMATICS

DETAIL: ROAD / DITCH STANDARD



JME WORLD CONSULTANTS

DRAFTING SERVICES LTD

ROSSER CENTREPORT

MUNICIPAL DITCH PROFILES

RM OF ROSSER
CENTREPORT CANADA
RM OF FOSSER

SHEET 4 OF 4

CAD FILE DRAWING NAME JME-001

DRAWING NUMBER

JME World Consultants
jess@jme-consultants.com
www.jme-consultants.com
204-330-1773

DESIGNED TVS

DRAWN TVS

SCALE 1:15,000

PROJECT NUMBER 1404039

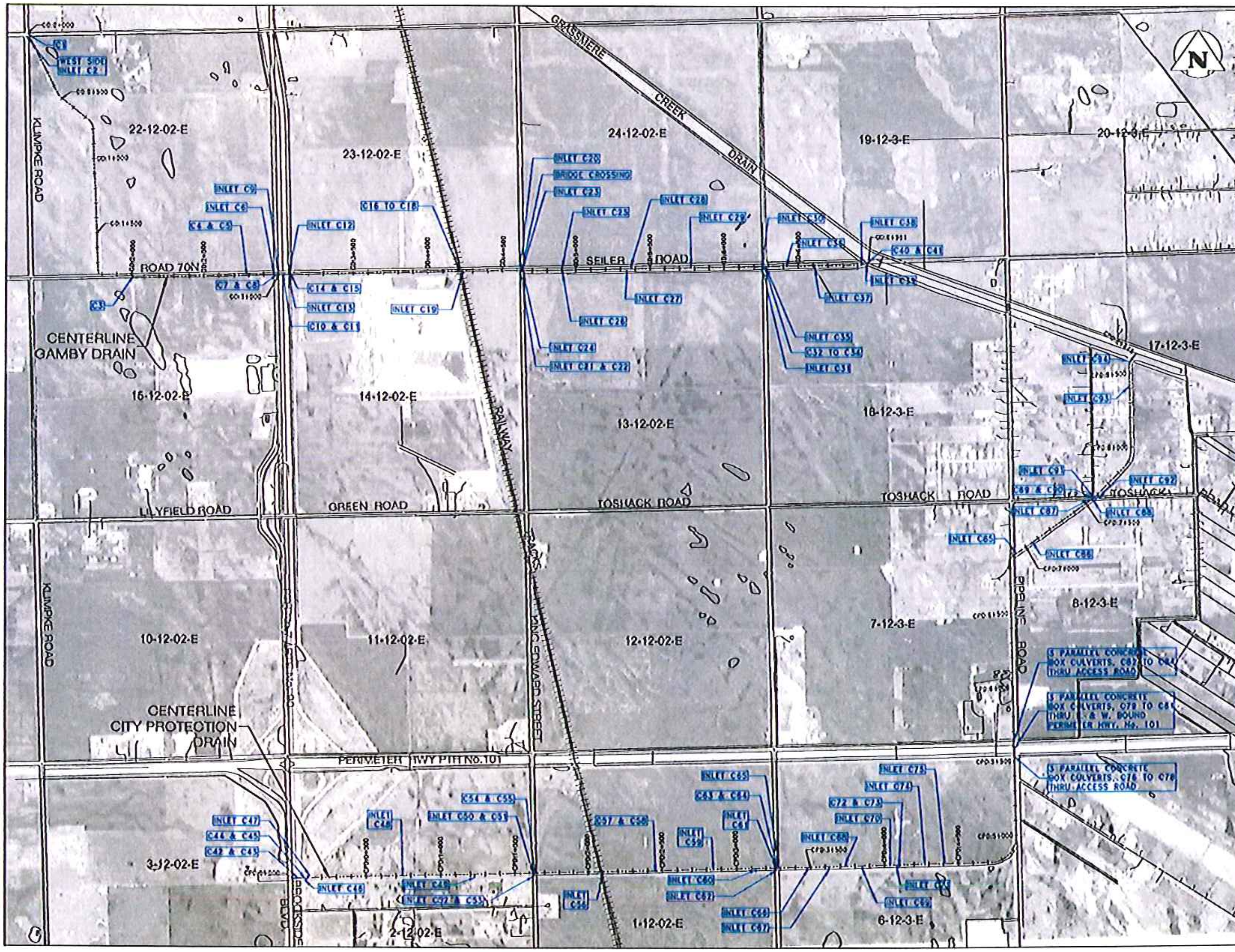
DATE DRAWN NOV 20, 2015

DATE OF SURVEY VARIES

APEGM Certificate of Authorization JESSICA MANNESS ENGINEERING P.C. No. 5534

J.A. MANNESS Member 23874

JME-001-4



NOTES:

1. ALL DIMENSIONS ARE IN METRES AND MAY BE CONVERTED TO FEET BY MULTIPLYING BY 3.28084.
2. WHOLE NUMBERS INDICATE MILLIMETRES AND DECIMALIZED NUMBERS INDICATE METRES.
3. ELEVATIONS ARE GEODETIC AND ARE DERIVED FROM GPS OBSERVATIONS BASED ON THE CANNET VIRTUAL REFERENCE SYSTEM.
4. THIS SURVEY WAS MADE BETWEEN THE 29TH DAY OF SEPTEMBER, 2014 AND 1ST DAY OF OCTOBER, 2014.
5. CULVERTS IDENTIFIED AS "INLET" REPRESENT CULVERTS PERPENDICULAR TO THE DRAIN ALIGNMENTS AND CONTRIBUTE WATER TO THE RESPECTIVE DRAIN.
6. CULVERT INLET ELEVATIONS ARE SHOWN IN EXISTING CULVERTS TABLES FOR RESPECTIVE DRAINS, AS APPENDIX A FOR GAMBY DRAIN AND APPENDIX B FOR CITY PROTECTION DRAIN.

SCALE (24X36) - 1 : 12500

125 0 625 1250
Metres
1:12500

BARNES & DUNCAN

233 Fort Street
[illegible]
R3C 1E5

RM OF ROSSER

GAMBY DRAIN & CITY PROTECTION DRAIN PLAN

GD.0+000 - GD.6+931
& CPD.0+000 - CPD.8+645
RM OF ROSSER

DESIGNED AS	CHECKED KS	SHEET 1 OF 5
DRAWN AS	APPROVED KS	CAD FILE DRAWING NAME 14-[illegible] PROFILES_GAMBY-BCP_DRAINS
SCALE 24X36 1:12500 / SCALE 11X17 1:25000		
DATE DRAWN DEC. 23, 2014	DATE OF SURVEY OCT. 01, 2014	

EXISTING	LEGEND - TOPOGRAPHY/PLAN	PROPOSED
	DITCH CENTERLINE	
	PROPERTY BOUNDARY	
	CULVERT	
	ROADWAY	
	RAILWAY	
-0.5%	CULVERT TO CULVERT SLOPE	-0.5%

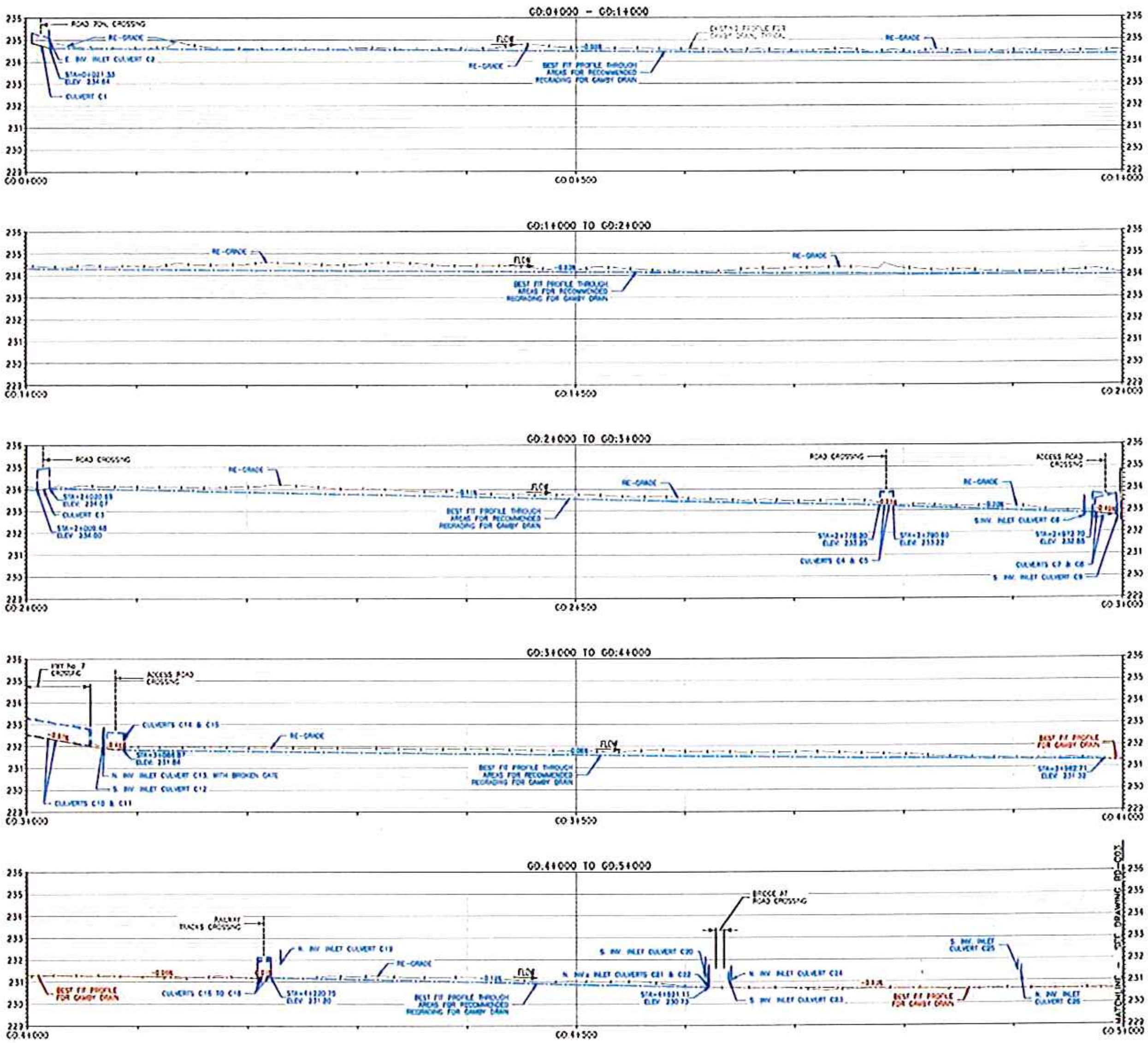
NO GEODETIC BENCHMARK REFERENCED FB --

NO	REVISIONS	DATE	BY	APP
0	SUBMITTED FOR REVIEW	[illegible]	AS	KS

APEGM
Certificate of Authorization
Barnes & Duncan
No. 3726

ENGINEER'S SEAL
PROVINCE OF MANITOBA
K.S. SHYMKO
Member
24532
REGISTERED PROFESSIONAL ENGINEER

CONSULTANT DRAWING NO
BD-001



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BARNES & DUNCAN

233 Fort Street
Winnipeg, Manitoba
R3C 1E5

RM OF ROSSER

GAVBY DRAIN PROFILES

GD:0+000 TO GD:5+000

RM OF ROSSER

DESIGNED AS	CHECKED KS	SHEET 2 OF 5
DRAWN AS	APPROVED KS	CAD FILE DRAWING NAME 14-1244 PROFILES_GAVBY-BOP_DRAINS
HOR. SCALE 1:4000 VER. SCALE 1:200		
DATE DRAWN DEC. 23, 2014	DATE OF SURVEY OCT. 01, 2014	

EXISTING	LEGEND-TOPOGRAPHY/PLAN	PROPOSED
	DITCH CENTERLINE	
	PROPERTY BOUNDARY	
	CULVERT	
	ROADWAY	
	RAILWAY	
-0.5%	CULVERT TO CULVERT SLOPE	-0.5%

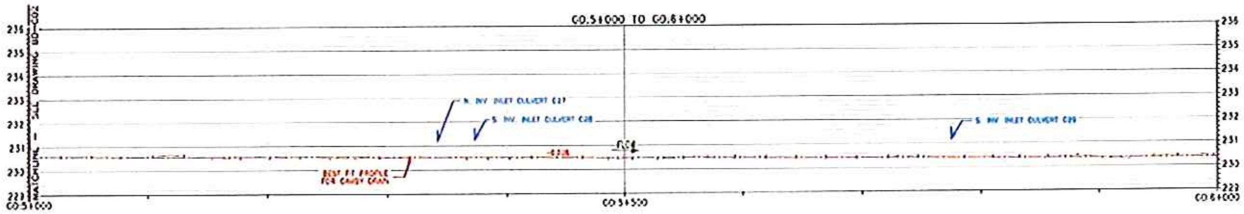
NO GEODETIC BENCHMARK REFERENCED FB --

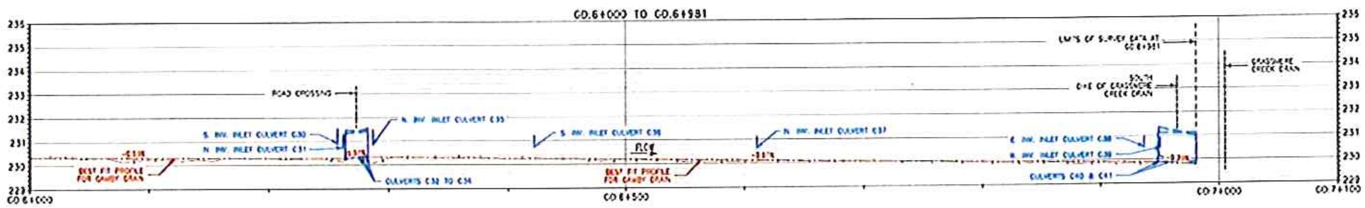
NO	REVISIONS	DATE	BY	APP
0	SUBMITTED FOR REVIEW	15/12/14	AS	KS

APEGM Certificate of Authorization Barnes & Duncan No. 3726

ENGINEER'S SEAL: PROVINCE OF MANITOBA K.S. SHYMKO Member 24532 REGISTERED PROFESSIONAL ENGINEER

CONSULTANT DRAWING NO. BD-C03





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BARNES & DUNCAN

218 Fort Street
Winnipeg, Manitoba
R3C 1E5

RM OF ROSSER

GAUBY DRAIN PROFILES
CO.5+000 TO CO.6+981
RM OF ROSSER

DESIGNED AS	CHECKED KS	SHEET 3 OF 3
DRAWN AS	APPROVED KS	CAD FILE DRAWING NAME 14-1248 PROFILES_GAUBY&CP_DRAINS
HOR. SCALE 1:4000 VER. SCALE 1:200		
DATE DRAWN DEC. 23, 2014	DATE OF SURVEY OCT. 01, 2014	

EXISTING	LEGEND - TOPOGRAPHY/PLAN	PROPOSED
	DITCH CENTERLINE	
	PROPERTY BOUNDARY	
	CULVERT	
	ROADWAY	
	RAILWAY	
-0.5%	CULVERT TO CULVERT SLOPE	-0.5%

NO GEODETIC BENCHMARK REFERENCED F.B. --

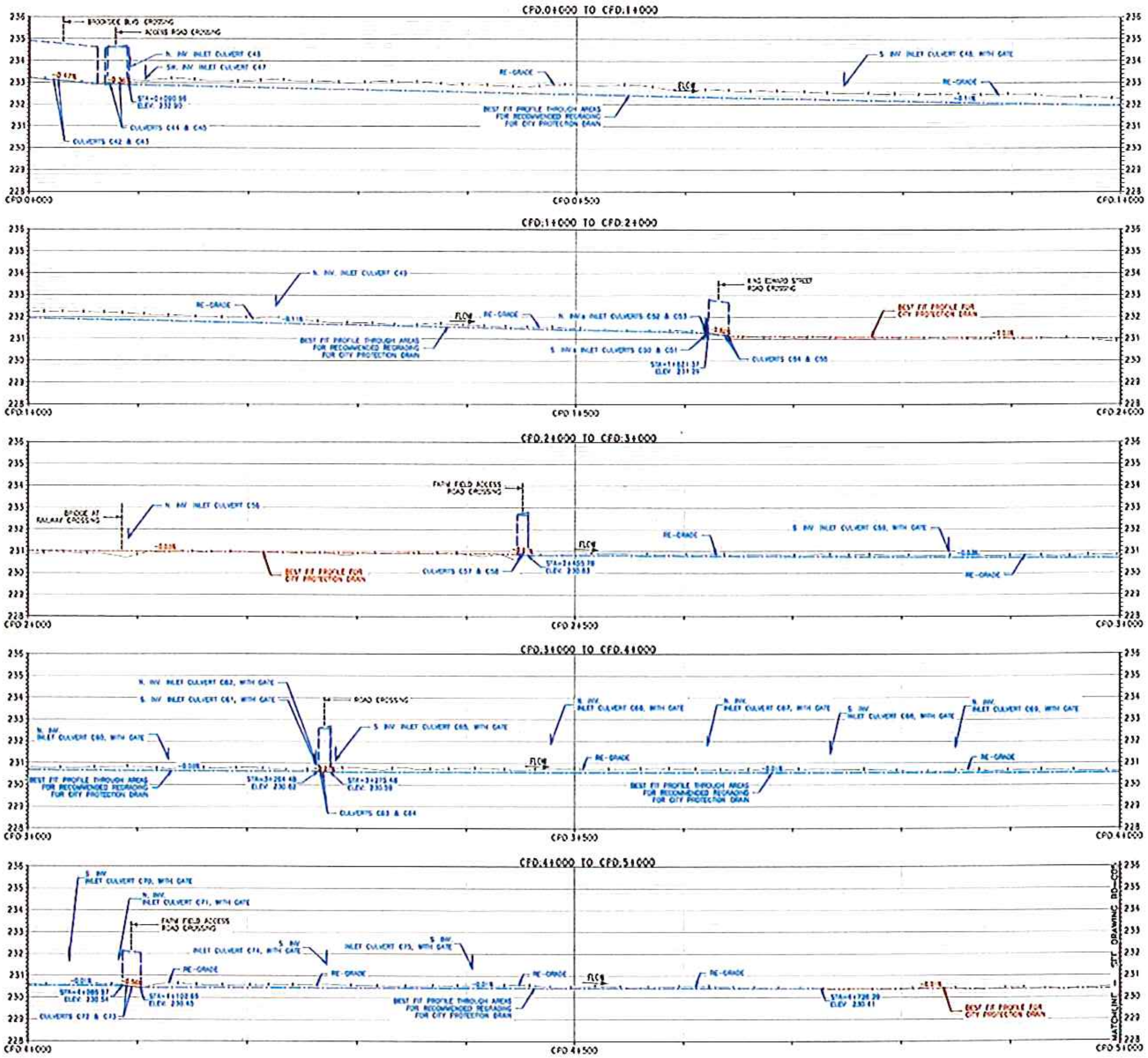
0	SUBMITTED FOR REVIEW	12/23/14	AS	KS
NO	REVISIONS	DATE	BY	APP

NOTES:
All distances are in metres and may be converted to feet by multiplying by 3.28084.

APEGM
Certificate of Authorization
Barnes & Duncan
No. 3728

ENGINEER'S SEAL
PROVINCE OF MANITOBA
K.S. SHYMKO
Member
24532
REGISTERED PROFESSIONAL ENGINEER

CONSULTANT DRAWING NO
BD-003



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BARNES & DUNCAN

228 Fort Street, Winnipeg, Manitoba R3C 1E5

RM OF ROSSER

CITY PROTECTION DRAIN PROFILES

CFD.0+000 TO CFD.5+000

RM OF ROSSER

DESIGNED AS	CHECKED KS	SHEET 4 OF 5
DRAWN AS	APPROVED KS	CAD FILE DRAWING NAME 14-1248 PROFILES_GAMBY&CP_DRAINS
HOR. SCALE 1:4000 VER. SCALE 1:200		
DATE DRAWN DEC. 23, 2014	DATE OF SURVEY OCT. 01, 2014	

EXISTING	LEGEND - TOPOGRAPHY/PLAN	PROPOSED
	DITCH CENTERLINE	
	PROPERTY BOUNDARY	
	CULVERT	
	ROADWAY	
	RAILWAY	
-0.5%	CULVERT TO CULVERT SLOPE	-0.5%

NO GEODETIC BENCHMARK REFERENCED F.B. --

NO	REVISIONS	DATE	BY	APP
0	SUBMITTED FOR REVIEW	[illegible]	AS	KS

NOTES:

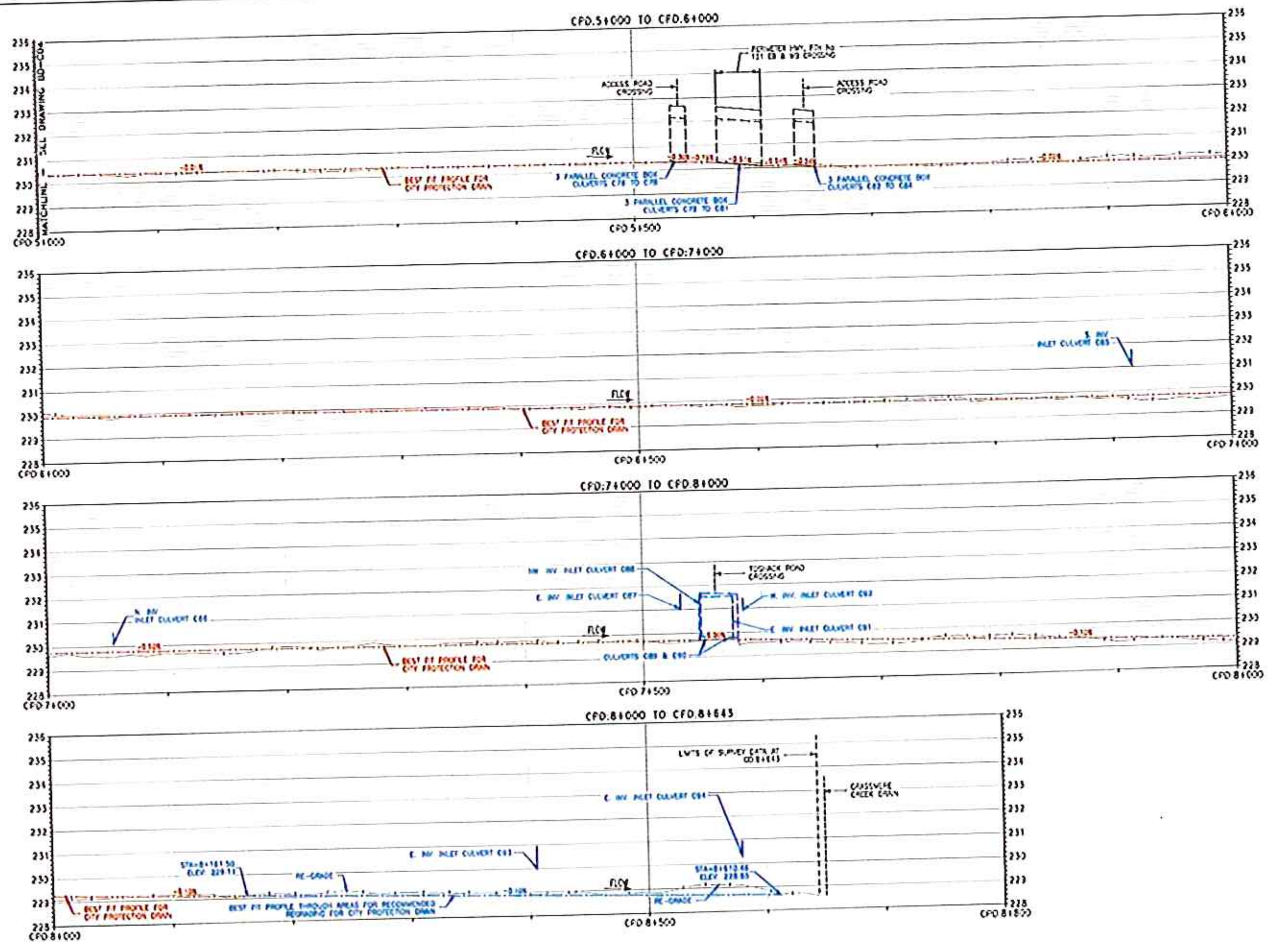
All distances are in metres and may be converted to feet by multiplying by 3.28084.

APEGM Certificate of Authorization Barnes & Duncan No. 3728

ENGINEER'S SEAL

PROVINCE OF MANITOBA K.S. SHYMKO Member 24532 REGISTERED PROFESSIONAL ENGINEER

CONSULTANT DRAWING NO. BD-004



NOTES:

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BARNES & DUNCAN

233 Fort Street
Winnipeg, Manitoba
R3C 1E5

RM OF ROSSER

CITY PROTECTION DRAIN PROFILES

CFD.5+000 TO CFD.8+645

RM OF ROSSER

DESIGNED AS	CHECKED KS	SHEET 5 OF 5
DRAWN AS	APPROVED KS	CAD FILE DRAWING NAME 14-1244 PROFILES_CAMBY/CP_DRAINS
HOR. SCALE 1:4000 VER. SCALE 1:200		
DATE DRAWN DEC. 23, 2014	DATE OF SURVEY OCT. 01, 2014	

EXISTING	LEGEND - TOPOGRAPHY/PLAN	PROPOSED
	DITCH CENTERLINE	
	PROPERTY BOUNDARY	
	CULVERT	
	ROADWAY	
	RAILWAY	
-0.5%	CULVERT TO CULVERT SLOPE	-0.5%

NO GEODETIC BENCHMARK REFERENCED F.B. --

NO.	REVISIONS	DATE	BY	APP
0	SUBMITTED FOR REVIEW	[illegible]	AS	KS

NOTES:
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APEGM
Certificate of Authorization
Barnes & Duncan
No. 3728

ENGINEER'S SEAL
PROVINCE OF MANITOBA
K.S. SHYMKO
Member
24532
REGISTERED PROFESSIONAL ENGINEER

CONSULTANT DRAWING NO.
BD-C05

PROVINCE OF MANITOBA DRAINAGE POLICY

FOR DRAINS ALONG AND THROUGH PROVINCIAL HIGHWAYS AND ROADS

Feb. 1990

HYDRAULIC DESIGN STANDARDS

	THRU GR		SIDE DITCHES	
	DESIGN	MIN CULV	DESIGN	MIN CULV
P.T.H.	2%	750 mm	3%	600 mm
P.R.	3%	600 mm	5%	450 mm
MAIN MARKET ROADS (LGD, UNO.)	3%	600 mm	5%	450 mm
50/50 ROADS (L.G.D, UNO.)	5%	450 mm	10%	450 mm

Responsibility when Drains or Highways are being Upgraded.

CATEGORY	CONSTRUCTION			MAINTENANCE		
	DRAIN WITHIN HIGHWAY R. OF W.		THROUGH GRADE STRUCTURES	DRAIN WITHIN HIGHWAY R. OF W.		THROUGH GRADE STRUCTURES
	DRAIN	STRUCTURES AFFECTED		DRAIN	ALL STRUCTURES	
3[rd] ORDER DRAINS AND HIGHER BEING CONSTRUCTED OR RE-CONSTRUCTED BY WATER RESOURCES (W.R.), CONSERVATION DISTRICTS (C.D.), MUNICIPALITIES (MUN.) AND LOCAL GOVERNMENT DISTRICTS (L.G.D.)	W.R. C.D. MUN. L.G.D.	W.R. C.D. MUN. L.G.D.	W.R. C.D. MUN. L.G.D.	EXTRAORDINARY MAINTENANCE W.R., C.D., MUN., L.G.D. ROUTINE MAINTENANCE OF DRAIN, SUCH AS MOWING AND BRUSH CONTROL -WILL BE DONE BY D.H.T. EXTRAORDINARY MAINTENANCE INVOLVES eg. EROSION CONTROL	W.R. C.D. MUN. L.G.D.	D.H.T.
2[nd] ORDER DRAINS AND LOWER BEING CONSTRUCTED OR RE-CONSTRUCTED BY CONSERVATION DISTRICT, MUNICIPALITY AND LOCAL GOVERNMENT DISTRICT.	MUN. C.D. L.G.D.	MUN. C.D. L.G.D.	MUN. C.D. L.G.D.	D.H.T. THIS WILL INCLUDE ROUTINE AND EXTRAORDINARY	D.H.T.	D.H.T.
CONSTRUCTION OR RE-CONSTRUCTION OF PROVINCIAL HIGHWAYS BY D.H.T. AFFECTING ANY CATEGORY OF DRAIN, i.e. WHERE HIGHWAY CONSTRUCTION WILL ENCROACH ON EXISTING DRAIN.	D.H.T.	D.H.T.	D.H.T.	*D.H.T. ROUTINE AND EXTRAORDINARY	*D.H.T.	D.H.T.

*EXCEPT PROVINCIAL WATERWAYS, RESPONSIBILITY TO BE 100% W.R. AND/OR C.D.s WHERE C.D.s HAVE TAKEN OVER W.R. RESPONSIBILITIES FOR DRAIN AND STRUCTURES.

Responsibility when Structures only have to be replaced due to Failure or Obsolescence.

CATEGORY	CONSTRUCTION			MAINTENANCE	
	REPLACEMENT OF EXISTING STRUCTURE		NEW ACCESS STRUCTURE	NEW, REPLACED OR EXISTING STRUCTURE	
	DRAIN WITHIN HIGHWAY R. of W.	THROUGH GRADE	DRAIN WITHIN HIGHWAY R. of W.	DRAIN WITHIN HIGHWAY R. of W.	THROUGH GRADE
3[rd] ORDER DRAIN AND HIGHER BELONGING TO WATER RESOURCES, CONSERVATION DISTRICTS, MUNICIPALITIES AND LOCAL GOVERNMENT DISTRICTS.	W.R. C.D. MUN. L.G.D.	D.H.T.	W.R. C.D. MUN. L.G.D. APPLICANT	W.R. C.D. MUN. L.G.D.	D.H.T
2[nd] ORDER DRAIN AND LOWER BELONGING TO CONSERVATION DISTRICTS, MUNICIPALITIES AND LOCAL GOVERNMENT DISTRICTS.	D.H.T	D.H.T.	MUN. C.D. L.G.D. APPLICANT	D.H.T	D.H.T

Approved:

Originally Signed by Albert Driedger
Hon. A. Driedger
Minister Highways & Transportation

Originally Signed by Harry Enns
Hon. H. Enns
Minister Natural Resources

Originally Signed by Jack Penner
Hon. J. Penner
Minister Rural Development

Manitoba

Manitoba Water Stewardship
Water Control Works and Drainage Licensing Section
Subdivision Drainage Plan Requirements Fact Sheet

This Factsheet is intended for proponents of urban residential, rural residential, urban commercial and rural commercial subdivision developments.

The Water Rights Act as it relates to Subdivision Development

The Water Rights Act suggests that no person shall control water or construct, establish or maintain any water control works unless he or she holds a valid license to do so.

Water control works are defined as any dyke, dam, surface or subsurface drain, drainage, improved natural waterway, canal, tunnel, bridge, culvert borehole or contrivance for carrying or conducting water, that temporarily or permanently alters or may alter the flow or level of water, including but not limited to water in a water body, by any means, including drainage, OR changes or may change the location or direction of flow of water, including but not limited to water in a water body, by any means, including drainage.

If the proposal in question advocates any of these activities, please apply for a Water Rights License to Construct Water Control Works.

Application for a Water Rights Licence

- To apply for a water rights license, a completed license application form along with the license fee must be submitted to Manitoba Water Stewardship at the address indicated on the application form.
- Application forms can be obtained from Water Stewardship in Winnipeg or from Water Stewardship Regional Offices. Please contact either:

Eastern MB (Winnipeg, Capital Region and surrounding area)
Geoff Reimer at (204) 467-4450, geoff.reimer@gov.mb.ca, Box 4558, Stonewall, MB R0C 2Z0

Western MB (Brandon and surrounding area)
Ed Mackay at (204) 726-6226, ed.mackay@gov.mb.ca, 1129 Queens Ave., Brandon, MB R7A 1L9

for more information concerning obtaining an application form or preparing and submitting a license application.

Engineering Design and Analysis

The following information is required in a subdivision development drainage plan submitted for review by Water Stewardship.

- With exceptions that may be granted by Water Stewardship, subdivision storm water management and drainage plans shall be designed by a professional engineer registered to practice in the Province of Manitoba. The construction of the water control works shall be in accordance with the methods and materials as specified by the engineer.
- The Applicant shall submit two (2) copies of the design drawings of the reservoir and associated works approved by the engineer to Water Stewardship for assessment.
- Developments totaling less than 10 lots (total) in size with lot sizes larger than 2 acres may, in some instances, be subject to less stringent engineering design requirements. Nevertheless, the design and construction of the project shall still be completed in accordance with acceptable engineering standards. The Applicant may be required to provide technical drawings showing design and construction details.
- Where Water Stewardship determines it to be appropriate, we may direct the Applicant to carry out an engineering analysis of hydrologic regime changes, potential physical impacts, and proposed mitigation measures.

Drainage Plan Requirements:

Hydraulic Design Requirements:

- Hydraulic design calculations are to be provided for review using a design scenario which details how post development storm water runoff rates of the subject property are to be equal to or less than pre development runoff rates subject to the following criteria.*
- Site must be able to handle, up to and including, a 1 in 25 year design storm event. Ponding volume equals the difference between a 1 in 5 year allowable outflow and a 1 in 25 year post development flow hydrograph. The allowable outflow is the 1 in 5 year peak flow based on pre-development conditions. The ponding storage is typically accomplished through retention ponds or internal storage via ditches and drainage patterns
- The storm duration for the design should be 3 hours.
- Report must clearly detail:
  - Pre-development catchment area runoff volumes and rate for design event
  - Post development catchment area runoff volumes and rate for design event
  - Volume of water to be stored and proposed outflow rate
- In cases where increased post development runoff can not be accommodated within the development -- the engineering plan must detail how the developer will mitigate negative downstream impacts that may result due to the increase in surface water flows.**

* Please note that if the development intends to outlet through Manitoba Infrastructure and Transportation infrastructure (highways or PR culvert) then different drainage standards may apply – please contact MIT for details

** Mitigation may include the upgrading of existing drainage infrastructure such as culverts and drainage channels downstream to accommodate additional runoff.

Engineered Site Plans Requirements:

- Detailed engineering plans outlining any construction, alteration, improvement, blocking or modification of new or existing drainage works servicing the property.
- Drain flow direction(s)
- Proposed/Existing culvert sizes and locations and/or schematics of any buried land drainage system
- Detailed design drawings of proposed storm water storage works
- Typical cross sections of proposed drains and ditches
- Existing and proposed geodetic lot grade elevations (in metric)
- Public right-of-ways or easements.
- Outlet of proposed drainage works (where the water exits the development) to be licensed in accordance to *The Water Rights Act* incorporating the above mentioned criteria.

The above list of requirements is specific to the surface water drainage aspect of a development only. Due to the nature of surface water drainage there are other agencies that may have input as to drainage standards and requirements due to the nature of their infrastructure and mandate. Agencies which may require further hydraulic and hydrologic information related to surface water runoff from subdivisions include:

- Manitoba Infrastructure and Transportation (MIT) – this Provincial Department owns and operates the provincial drain and public road system throughout Manitoba. Their road and drainage infrastructure is significantly impacted by surface water runoff, and if a development's drainage outlets through or into provincial infrastructure then MIT's approval will be required.
- Water Stewardship's Forecasting and Flood Coordination Branch may require minimum flood protection level (FPL) elevations if development is located within flood fringe area. Existing and proposed geodetic lot grade elevations (in metric) both on the site and on adjacent property, public right-of-ways or easements.
- Federal Department of Fisheries and Oceans (DFO) – any surface water drainage works that impact fish habitat will require the separate approval of DFO. DFO determines whether the proposed development will have a potential impact on fish habitat, and will require compensation for any potential destruction of fish habitat caused by alteration of existing drainage works. It is entirely the responsibility of the proponent to contact DFO in Winnipeg at (204) 983-5220.
- Your municipality
- Other regulatory agencies as required.

The approval of a drainage plan does not mean that developments that are adjacent to or encroaching on natural waterways are not at risk from overbank or overland flooding during extreme runoff events. There may be instances where overbank or overland flooding occurs during periods of extreme precipitation or spring runoff.

RM OF ROSSER
LOT GRADE DESIGN STANDARDS

The Rural Municipality of Rosser Lot Grade Design Standards shall apply: ·

(a) Where a Lot Grade Plan and Drainage Plan are overlaid in a single drawing or depicted separately on multiple pages, and the Lot Grade Plan and Drainage Plan are submitted together as part of a drawing set.

(b) Where the subject lot is part of a greater area that has stormwater control measures in place and where the design of the stormwater control measures include the potential post-development runoff for the subject lot. In this case, the lot grade design must meet the criteria used for the stormwater control design plus must meet the requirements outlined in the Lot Grade Design Checklist.

(c) Where a Drainage Plan for the subject area was previously approved and the lot owner wishes to proceed with development of the lot using the Drainage Plan design criteria that were used for calculating the Drainage Plan.

(d) Where deemed necessary, as determined by Council.

LOT GRADE PLAN DESIGN CHECKLIST

A Lot Grade Plan shall contain the following information:

- Plan(s) prepared and sealed by a Professional Engineer or Professional Architect.
- Contact information of the firm preparing the plan(s).
- Address and description of the property including: client, legal address, civic address.
- Existing and proposed elevations referenced to the geodetic datum and tied to the City of Winnipeg BM 03-010 - elevation 235.568 m, referenced benchmark noted on the drawing.
- Drawing scale (typically metric) (no less than 1:200 for Residential or 1:500 for Commercial).
- North arrow.
- Temporary benchmark (cut, nail, etc.) established near the site and noted on the drawing.
- Existing and proposed lot grade elevations shown on the development site at corners and at any split grade locations.
- Some existing elevations on the adjacent properties, ditches, and public ROW's.
- Approximate dimensions of all property lines and total area of each lot.
- As applicable, details of proposed and existing building, including:
  - Location(s) and approximate distances to between buildings, property lines, driveways, etc.
  - Main floor elevation for concrete slab foundations.
  - Location of entrances to buildings and proposed landscape elevation.
  - Identification of the location of a well, septic tank, or connections to municipal services.
  - Location of roof drain downspouts and sump pump discharge.
- Location and dimensions of all paved or impervious areas such as parking lots, lanes, driveways, sidewalks, curbs, and gutters.
- A detail of any concrete, asphalt, or gravel pavement areas.
- Catch basin locations (existing and proposed) with rim and invert elevation, pipe locations, discharge location, outlet invert, and outlet treatment (splash pad).
- Grades described in percentages; defined grade split locations (dashed lines).
- Swale and drain locations, slope, and detail.
- Retaining walls defined by length, location, and type. Construction detail for walls greater than 150 mm tall.
- Driveway access points, sizes, and culvert inverts.
- Landscape buffer area and other sustainable development measures identified.
- Indicate vegetation of any exposed soil, duration and type of erosion/sediment control measures.

RM OF ROSSER
DRAINAGE PLAN DESIGN STANDARDS

The following are the Rural Municipality of Rosser Drainage Plan Design Standards. Drainage Plans shall conform to the following.

1. A Drainage Plan must control a 1:50-year post-development runoff flow to a 1:5-year pre-development runoff flow rate with a design event of no less than 1 hour.
2. Typical detention and retention areas must have the capacity to hold the detained runoff volume of a 1:50 year event for a 3-hour storm duration.
3. Stormwater retention in surface ponds is not permitted in the Rosser CentrePort Lands.
4. Where an existing drain crosses through a property, a 10 m vegetative buffer is required between the top of the bank and the edge of any proposed asphalt, concrete, or gravel surface. Direct runoff from hard surfacing is not permitted to flow directly into the waterway without runoff velocity control measures.
5. Existing drainage paths and channels cannot be blocked: design must manage the surface water that passes through the development area.
6. Sediment, oil, chemical, and other contaminants must be prevented from introducing pollutants to the runoff water. Refer to Manitoba Regulations and local By-laws.
7. Sustainable surface water runoff management techniques must be included in the design and may be used to reduce the potential runoff. Refer to the Rosser CentrePort Lands Drainage Report for additional design options. Some examples of sustainable water management techniques include:
   a) Dry river channel
   b) Dry well / cistern
   c) Dry pond / detention pond
   d) Use of weir or control pipes at outlets
   e) Vegetative erosion control and sediment traps
   f) Permeable paving with rock bedding or dry well below
   g) Flat roof – rooftop rainfall detention storage
   h) Landscape buffering with deep rooting vegetation
8. Mechanical methods of sediment trapping and erosion control shall be included in the construction phase to the permit establishment of permanent vegetation.
9. Note that additional licences and approvals may be required.

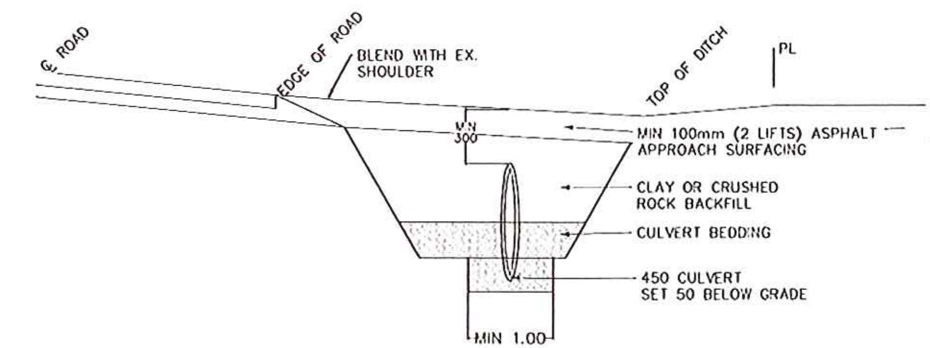
DRAINAGE PLAN DESIGN CHECKLIST

A Drainage Plan shall contain the following information:

- Plan(s) prepared and sealed by a Professional Engineer.
- Contact information of the firm preparing the plan(s).
- Address and description of the property including: client, legal address, civic address.
- Existing and proposed elevations referenced to the geodetic datum and tied to the City of Winnipeg BM 03-010 - elevation 235.568 m, referenced benchmark noted on the drawing.
- Drawing scale (typically metric) (no less than 1:200 for Residential or 1:500 for Commercial).
- North arrow.
- Temporary benchmark (cut, nail, etc.) established near the site and noted on the drawing.
- Existing and proposed lot grade elevations shown on the development site at corners and at any split grade locations.
- Some existing elevations on the adjacent properties, ditches, and public ROW's.
- Approximate dimensions of all property lines and total area of each lot.
- As applicable, details of proposed and existing building, including:
    - Location(s) and approximate distances to between buildings, property lines, driveways, etc.
    - Main floor elevation for concrete slab foundations
    - Location of entrances to buildings and proposed landscape elevation
    - Location of roof drain downspouts and sump pump discharge
    - Identification of the location of a well, septic tank, or connections to municipal services
- A detail of any concrete, asphalt, or gravel pavement areas.
- Location and dimensions of all paved or impervious areas such as parking lots, lanes, driveways, sidewalks, curbs, and gutters.
- Catch basin locations (existing and proposed) with rim and invert elevation, pipe locations, discharge location, outlet invert, and outlet treatment (splash pad).
- Drainage patterns indicated by flow arrows and slopes described in percentages; defined grade split locations (dashed lines).
- Swale and drain locations, slope, and detail.
- Retaining walls defined by length, location, and type. Construction detail for walls greater than 150 mm tall.
- Driveway access points, sizes, and culvert inverts; complies with Approach Standard.
- Landscape buffer area and other sustainable development measures identified.
- Indicate vegetation of any exposed soil, duration and type of erosion/sediment control measures.
- Landscape buffer area and other sustainable development measures identified.
- Show calculations for the pre- and post-development runoff including control mechanisms to reduce the uncontrolled 50-year post-development flow to a 5-year pre-development flow using a minimum of a 1-hour storm.
- Provide storage area and show calculations for a 3-hour duration 50-year controlled event.

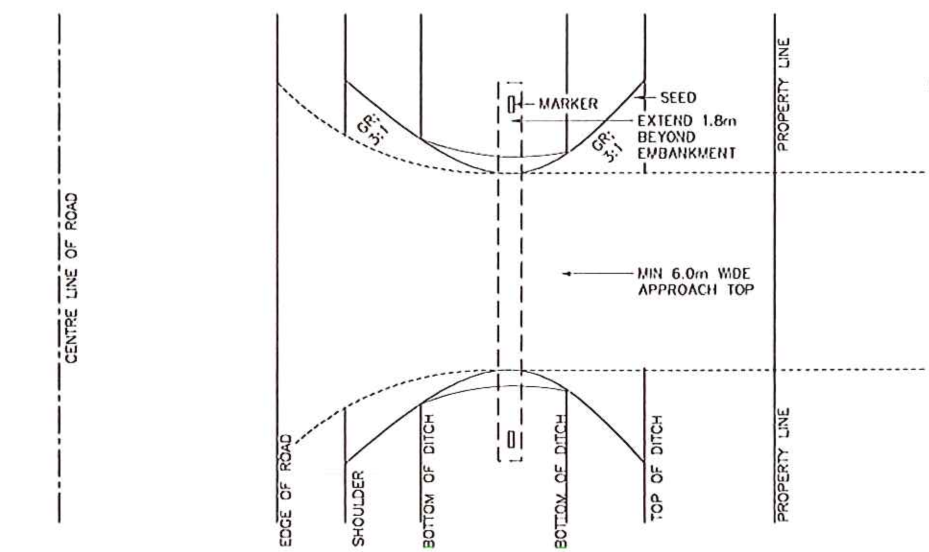
APPROACH CROSS SECTION DETAIL

NTS



APPROACH PLAN VIEW

NTS



General Notes:

This drawing is applicable when culvert approach details are not otherwise specified in a development drainage plan.

All construction must conform to applicable laws and regulations. Permits must be acquired prior to commencing work.

It is the contractor's responsibility to confirm all utility locations prior to commencing any construction.

Material Specifications:

The RM of Rosser accepts the following culvert types:
- 16 Ga Corrugated Metal Pipe (CMP) complying with CAN/CSA-G40I.
- Precast Concrete Pipe (PCP) complying with ASTM Specifications C-I4, C-76, or C-655

Culverts must be a minimum diameter of 450mm or specified by engineering design.

Bedding shall meet the following:
- 19mm crushed gravel

Acceptable backfill material includes:
- Impervious clay
- 50mm crushed rock
- cement stabilized fill

Capping for side slopes shall be impervious clay material

Vegetation shall be topsoil and seed or biotic earth hydroseed

Culvert end markers shall be 1500mm -30mm Ø orange Steelcor CSP culvert markers with 50mm reflective strip placed 25mm from the top of the marker, mounted on steel bracket and held with two bolts.

Construction Details:

Contractor to stake grades, then call for inspection a minimum of 48 hours prior to commencing work.

Over-excavate by 155mm for installation of bedding below the design culvert invert.

Install 19mm crushed gravel bedding to underside of design culvert invert. Compact to 98% standard proctor density using backhoe bucket or vibratory packer. Confirm compaction by proof-rolling. 19mm thick sand may be used on top of bedding as a leveling course.

Install culvert at the design grade.

Install gravel bedding in 150mm lifts to half-way up the culvert, compacting each lift to 98% standard proctor density.

Fill with backfill to underside of driveway paving material, compacting each lift to 98% standard proctor density.

Side slopes are to be capped and sloped a min of 1h:3v.

Apply topsoil and seed or biotic earth hydroseed.

Culvert ends to be left blunt and protruding a min 1.8m from the end of the embankment.

Install culvert end markers on both ends of culvert by bolting with plated bolts, nuts, and washers in field-drilled mounting holes.

MUNICIPALITY OF ROSSER

STANDARD INDUSTRIAL APPROACH DETAIL

JME World Consultants
jess@jme-consultants.com
www.jme-consultants.com
204-330-1773

APEGM Certificate of Authorization JESSICA MANNESS ENGINEERING INC. No. 5534

BM: City of Winnipeg 03-010
ELEV.: 235.568m

NO	REVISIONS	DATE	BY
1	IFC	JUNE 2016	JAM

Rosser CP EC Rainfall Data
Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2014/12/21

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WINNIPEG HANGARLINE ROAD MB 5023224
(composite)
Latitude: 49 55'N Longitude: 97 14'W Elevation/Altitude: 238 m

Years/Années : 1944 - 1996 # Years/Années : 49

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Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

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Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1944	14.7	18.8	25.1	37.3	39.9	41.7	45.0	49.0	75.9
1945	13.7	15.5	19.8	27.2	31.5	33.8	42.9	45.2	48.3
1946	5.6	6.1	7.1	8.6	10.2	14.2	20.6	21.3	25.1
1947	8.4	11.4	13.5	19.6	22.1	28.2	45.0	45.0	45.2
1948	9.1	11.7	13.2	17.3	30.5	33.3	33.3	36.6	37.3
1951	5.8	6.1	9.1	15.7	16.0	17.8	21.1	21.1	36.3
1952	9.1	17.8	22.4	28.4	29.2	43.7	43.7	43.7	43.7
1953	10.2	15.5	19.3	24.6	30.2	31.2	41.7	43.4	43.4
1954	9.7	12.2	12.7	16.0	18.3	21.1	25.9	28.7	35.8
1956	6.1	9.7	13.5	17.8	18.3	18.3	29.2	33.8	55.1
1958	8.9	10.9	15.7	17.8	18.5	19.8	35.8	50.3	67.1
1959	9.4	15.5	18.8	19.6	19.6	22.4	37.6	42.2	44.7
1960	4.3	5.6	7.4	8.1	8.1	11.7	27.9	32.8	41.1
1961	6.1	8.6	10.2	13.2	17.3	19.8	21.8	26.4	34.0
1962	11.2	14.7	19.6	27.4	35.8	56.1	82.3	83.1	83.8
1963	7.6	11.9	16.5	18.5	21.1	24.1	38.9	50.5	52.8
1964	6.9	12.2	17.5	22.4	33.5	36.8	38.1	52.3	59.2
1965	6.1	9.1	11.7	14.5	15.7	16.8	17.8	21.1	30.2
1966	9.1	12.7	15.2	22.6	37.8	64.0	68.3	73.2	76.2
1967	12.2	24.1	25.9	31.7	33.0	57.9	63.2	63.5	63.5
1968	17.8	24.6	35.3	39.4	39.4	39.4	48.3	61.2	84.3
1969	7.1	10.4	12.7	15.2	21.8	23.4	25.4	39.1	49.3
1970	11.2	20.8	29.0	37.8	41.1	49.8	54.9	60.5	62.2
1971	4.6	6.1	8.4	11.7	14.5	19.8	25.4	29.0	31.0
1972	9.1	16.5	20.3	35.6	35.6	35.8	35.8	35.8	35.8
1973	6.3	10.4	14.5	19.8	29.7	40.4	45.7	45.7	45.7
1974	9.4	16.3	18.8	25.1	28.7	33.0	37.1	38.9	55.4
1975	9.4	14.5	17.8	22.6	27.9	27.9	44.7	53.8	54.4
1976	15.0	15.7	18.0	21.8	22.1	24.1	26.2	33.3	42.7
1977	7.4	12.4	15.2	19.8	21.6	32.5	50.3	57.7	61.7
1978	10.6	17.6	21.6	24.5	28.0	41.7	52.6	52.6	60.4
1979	10.6	19.1	25.4	36.3	39.3	39.8	40.7	40.7	40.7
1980	7.4	8.8	10.4	15.0	19.3	24.5	25.6	26.6	30.5
1981	10.6	12.4	15.9	18.2	24.1	29.0	53.3	53.4	63.0
1982	8.6	13.0	16.2	22.6	22.7	22.7	32.5	34.9	36.8

Rosser CP EC Rainfall Data

1983	13.2	17.2	19.3	23.2	28.0	30.9	51.9	52.3	52.3
1984	12.6	19.0	22.8	39.5	56.2	56.9	60.2	69.5	69.7
1985	5.0	7.3	9.3	12.4	18.4	33.1	61.5	84.0	97.4
1986	10.0	11.8	13.9	16.7	18.5	19.7	28.7	35.4	41.6
1987	7.1	9.0	10.4	20.8	24.8	36.6	46.2	57.2	57.3
1988	7.9	15.8	18.5	22.7	34.8	36.9	39.7	49.7	49.7
1989	4.4	7.7	10.4	12.3	14.1	16.2	34.6	41.1	53.5
1990	9.8	12.7	16.2	19.0	22.0	22.0	22.0	22.5	36.9
1991	11.6	16.4	18.0	18.2	19.3	31.2	43.1	43.5	64.0
1992	8.6	10.2	11.2	17.2	18.0	19.3	21.2	25.2	35.6
1993	6.2	12.4	18.6	29.0	41.6	70.1	72.2	78.4	87.4
1994	8.8	13.1	15.4	24.2	32.2	55.5	67.0	68.2	68.2
1995	7.5	9.9	12.0	18.0	23.0	23.4	35.6	44.0	63.9
1996	8.1	16.1	21.9	43.8	58.6	58.6	58.8	58.8	58.8
# Yrs. Années	49	49	49	49	49	49	49	49	49
Mean Moyenne	9.0	13.2	16.6	22.3	26.8	32.8	41.3	46.0	52.8
Std. Dev. Écart-type	2.9	4.5	5.8	8.4	10.6	14.2	15.1	16.1	16.6
Skew. Dissymétrie	0.75	0.45	0.79	0.81	0.92	0.85	0.60	0.51	0.64
Kurtosis	3.90	3.20	4.28	3.30	4.27	3.19	3.08	2.99	3.14

*-99.9 Indicates Missing Data/Données manquantes

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1968	15 min	35.3	34.7

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Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

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Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	8.5	11.1	12.8	14.9	16.5	18.1	49
10 min	12.5	16.4	19.0	22.3	24.7	27.2	49
15 min	15.6	20.7	24.1	28.4	31.5	34.7	49
30 min	20.9	28.3	33.2	39.4	44.1	48.6	49
1 h	25.0	34.4	40.6	48.4	54.2	59.9	49
2 h	30.5	43.0	51.3	61.7	69.5	77.2	49
6 h	38.8	52.1	61.0	72.1	80.4	88.6	49
12 h	43.4	57.6	67.0	78.9	87.7	96.5	49
24 h	50.1	64.7	74.4	86.7	95.7	104.8	49

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Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

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Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années

Rosser CP EC Rainfall Data

5 min		102.1	132.8	153.1	178.7	197.8	216.6	49
	+/-	8.9	+/- 15.0	+/- 20.3	+/- 27.4	+/- 32.7	+/- 38.1	49
10 min		74.9	98.5	114.1	133.8	148.5	163.0	49
	+/-	6.9	+/- 11.6	+/- 15.6	+/- 21.0	+/- 25.2	+/- 29.3	49
15 min		62.5	82.9	96.4	113.4	126.1	138.6	49
	+/-	5.9	+/- 10.0	+/- 13.5	+/- 18.2	+/- 21.8	+/- 25.4	49
30 min		41.8	56.6	66.5	78.9	88.1	97.3	49
	+/-	4.3	+/- 7.3	+/- 9.8	+/- 13.3	+/- 15.9	+/- 18.5	49
1 h		25.0	34.4	40.6	48.4	54.2	59.9	49
	+/-	2.7	+/- 4.6	+/- 6.2	+/- 8.3	+/- 10.0	+/- 11.6	49
2 h		15.2	21.5	25.6	30.9	34.7	38.6	49
	+/-	1.8	+/- 3.1	+/- 4.1	+/- 5.6	+/- 6.7	+/- 7.8	49
6 h		6.5	8.7	10.2	12.0	13.4	14.8	49
	+/-	0.6	+/- 1.1	+/- 1.5	+/- 2.0	+/- 2.4	+/- 2.8	49
12 h		3.6	4.8	5.6	6.6	7.3	8.0	49
	+/-	0.3	+/- 0.6	+/- 0.8	+/- 1.1	+/- 1.3	+/- 1.5	49
24 h		2.1	2.7	3.1	3.6	4.0	4.4	49
	+/-	0.2	+/- 0.3	+/- 0.4	+/- 0.5	+/- 0.7	+/- 0.8	49

****

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	37.1	49.2	57.2	67.4	74.9	82.4
Std. Dev. /Écart-type (RR)	35.7	46.6	53.8	62.8	69.6	76.3
Std. Error/Erreur-type	10.1	15.0	18.2	22.2	25.3	28.3
Coefficient (A)	22.2	29.7	34.7	40.9	45.6	50.2
Exponent/Exposant (B)	-0.703	-0.703	-0.703	-0.702	-0.702	-0.702
Mean % Error/% erreur moyenne	10.4	12.4	13.3	14.0	14.5	14.8